VOL. 33, NO. 10 OCTOBER, 1956

AMERICAN JOURNAL OF OPTOMETRY *and* ARCHIVES *of* AMERICAN ACADEMY OF OPTOMETRY

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Published Monthly by the AMERICAN JOURNAL OF OPTOMETRY PUBLISHING ASSOCIATION, 1508 Foshay Tower, 821 Marquette Ave., Minneapolis 2, Minn.

ANNUAL SUBSCRIPTION, UNITED STATES and CANADA $7.00. FOREIGN $7.50.
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IOWA				
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Sioux City	Tue. Oct. 16	7-10 p.m.	A	Hotel Martin
Davenport	Wed. Nov. 7	7-10 p.m.	A	Hotel Blackhawk
NEBRASKA				
Omaha	Wed. Oct. 17	7-10 p.m.	A & B	Hotel Fontenelle
KANSAS				
Kansas City	Fri. Oct. 19	7-10 p.m.	A & B	The Town House
Wichita	Sun. Oct. 21	1-5 p.m.	A & B	Hotel Lassen
OKLAHOMA				
Oklahoma City	Mon. Oct. 22	7-10 p.m.	A & B	Oklahoma-Biltmore
Tulsa	Tue. Oct. 23	7-10 p.m.	A & B	The Mayo
ILLINOIS				
Peoria	Tue. Nov. 6	7-10 p.m.	A	Hotel Pere Marque
Rockford	Thur. Nov. 8	7-10 p.m.	A	Hotel Lafayette
Springfield	Tue. Nov. 13	7-10 p.m.	A & B	Abraham Lincoln
Chicago	Sun. Nov. 18	1-5 p.m.	A & B	Morrison
WISCONSIN				
Milwaukee	Fri. Nov. 9	7-10 p.m.	A & B	Hotel Schroeder
Madison	Fri. Nov. 9	7-10 p.m.	A	Hotel Loraine
MISSOURI				
St. Louis	Wed. Nov. 14	7-10 p.m.	A & B	Statler
INDIANA				
Evansville	Thur. Nov. 15	7-10 p.m.	A & B	Hotel McCurdy
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NEW JERSEY				
Newark	Wed. Oct. 3	7-10 p.m.	A	Hotel Essex House
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Paterson	Wed. Oct. 24	7-10 p.m.	A	The Alexander Ham
MARYLAND				
Baltimore	Tue. Oct. 9	7-10 p.m.	A	Lord Baltimore
DELAWARE				
Wilmington	Wed. Oct. 10	7-10 p.m.	A	Hotel DuPont
CONNECTICUT				
Bridgeport	Mon. Nov. 12	7-10 p.m.	A	Hotel Barnum
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Boston	Fri. Dec. 7	7-10 p.m.	A & B	Sheraton-Plaza
RHODE ISLAND				
Providence	Fri. Nov. 16	7-10 p.m.	A	Sheraton-Biltmore
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Philadelphia	Tue. Dec. 4	7-10 p.m.	A & B	Bellevue-Stratford
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Winston Salem	Sun. Dec. 9	1-5 p.m.	A & B	Hotel Robert E. Lee
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Savannah	Mon. Dec. 10	7-10 p.m.	A & B	Hotel DeSoto
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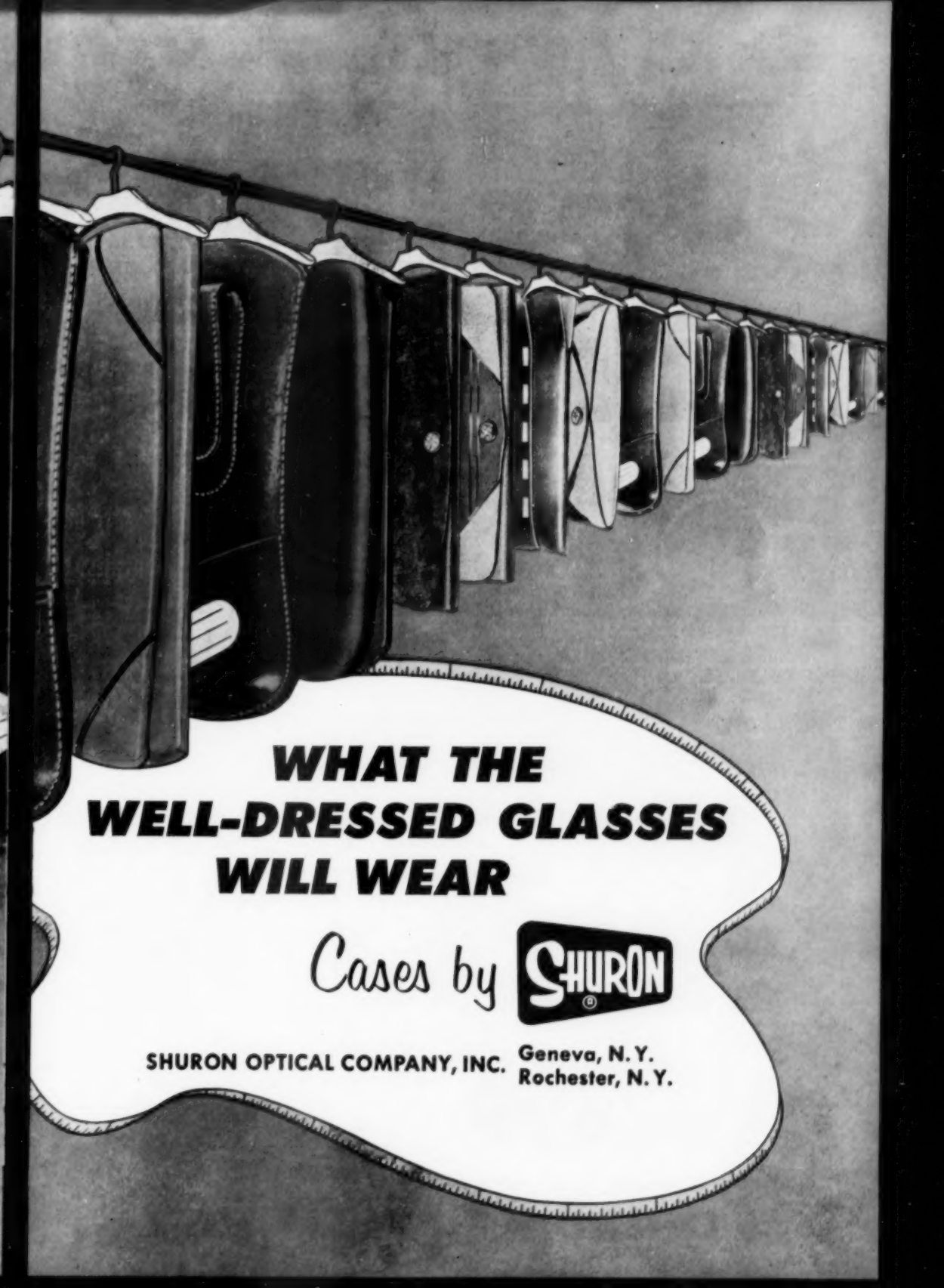
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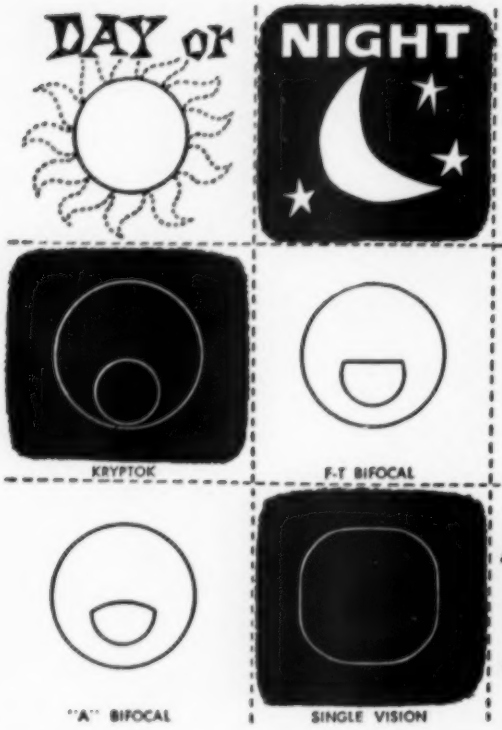

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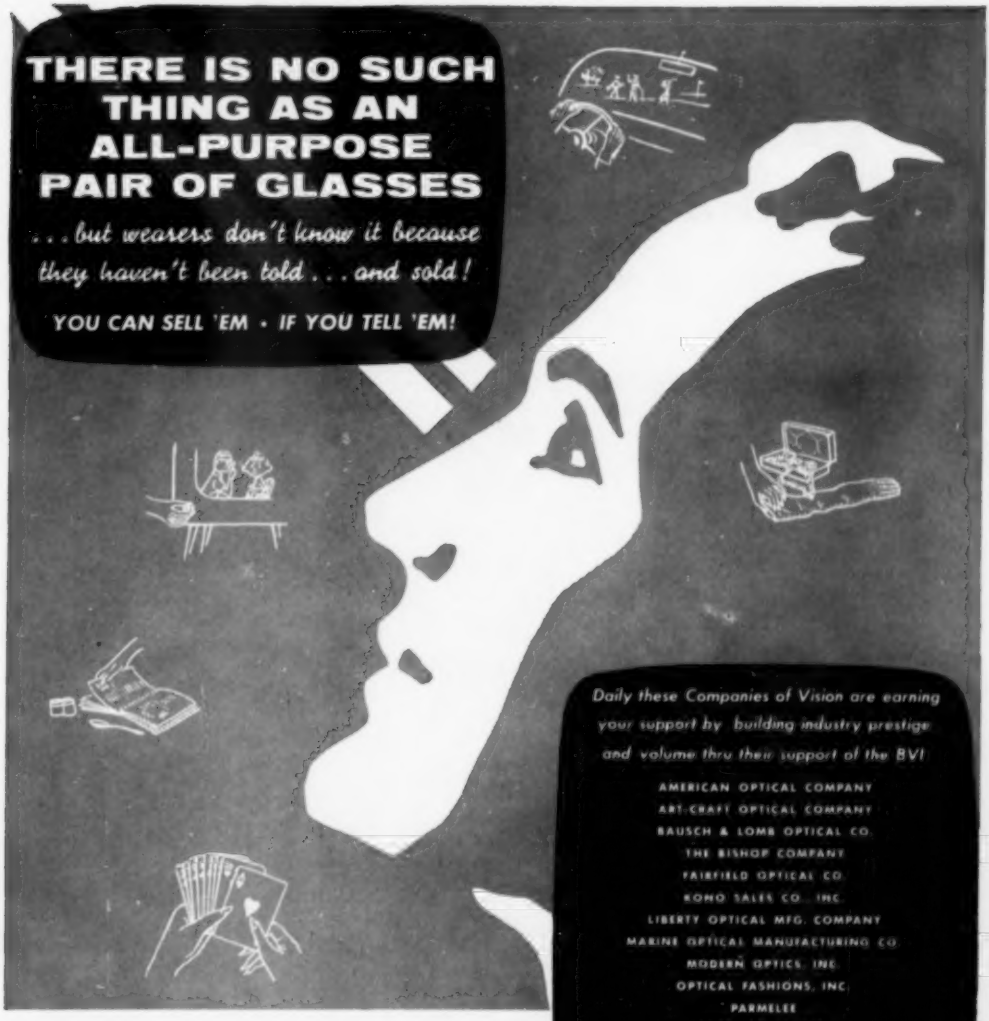

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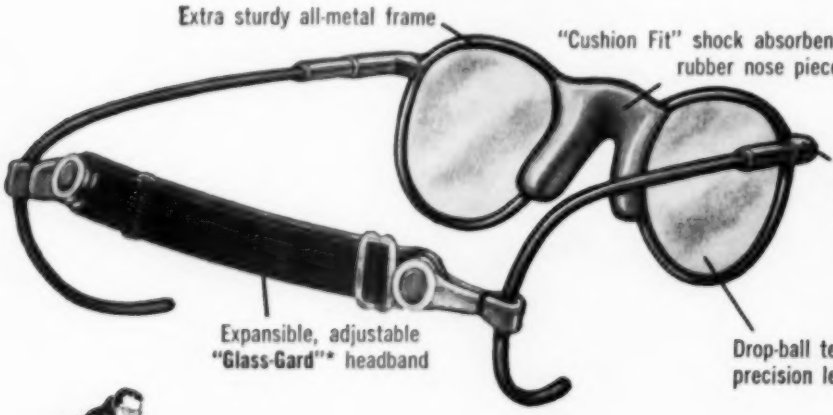
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THE INFLUENCE OF VISUAL ACUITY ON ACCOMMODATIVE RESPONSES OF THE EYE*

Gordon G. Heath†
School of Optometry, University of California
Berkeley, California

Some of our most detailed information regarding the accommodative mechanism and behavior of the eye has emerged in recent years from intensive studies of the phenomenon known as "nocturnal myopia." "Nocturnal myopia" or "night myopia" is so called because of a manifest increase in the refractive power of the eye under conditions of reduced illumination.[1] The causes of this apparent myopia have not yet been clearly resolved, and considerable controversy has evolved as to whether an actual change in accommodation occurs or whether the entire effect may be attributed to the spherical and chromatic aberrations of the eye.

Studies of the magnitude of noctural myopia have, in general, yielded average values of about 1.50 to 1.75 diopters. It has been shown that the aberrations of the eye, as affected by pupillary dilatation and the Purkinje shift of luminosity, probably contribute no more than about 0.7 D. of this.[2-9] A diopter, more or less, remains to be accounted for, and much evidence has been adduced to show that an actual change in accommodation occurs, though contrary results have also been obtained.[10] For example, the night myopia of absolute presbyopes and of aphakic subjects was found to correspond to the amount produced in normals by the ocular aberrations.[8] Atropinization of a normal eye greatly reduced the nocturnal myopia,[9, 11, 12] although it was also found that homatropine reduced it only in subjects whose spherical aberration was similarly reduced by the drug.[13] Flash photography of the Purkinje-Sanson images in total darkness has shown lens changes corresponding

*Read, in substance, before the First Western Regional Meeting of the American Academy of Optometry, Berkeley, California, April 11, 1954. From a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Physiological Optics. For publication in the October, 1956, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

†Optometrist. Fellow, American Academy of Optometry. Research Fellow, American Optometric Foundation. Now a member of faculty, Division of Optometry, Indiana University, Bloomington, Indiana.

to an accommodation of about the proper amount,[2, 14-16] but negative results have also been obtained by this method.[17, 18] Deep-red or infrared skiascopy has revealed increased amounts of accommodation in total darkness, but this was accompanied by large fluctuations of accommodation.[19]

As illumination is reduced, the amplitude or range of accommodation is also reduced.[21, 22] Both ends of the normal accommodative range are affected,[22, 23] the far point of the eye approaching and the near point receding, so that the observer becomes progressively more "presbyopic," as well as myopic, in very dim light. This phenomenon has been called "noctural presbyopia" and its existence has been verified by several investigators.[8, 9]

Implicit in the nocturnal myopia controversy is the assumption that it is the low level of luminance which is of basic importance in the phenomenon. However, Knoll[24] has called attention to the similar behavior of the eye under photopic conditions when the visual field is devoid of resolvable detail. Luckiesh and Moss,[25-29] with their sensitometric method of refraction, found the correction for "maximum visibility" to be an average of 0.75 D. more negative than the correction determined by usual clinical procedures. In their technique convergence was controlled by binocular observation of a blurred line at distance, while the luminance of the test field and the contrast of a special test object were increased until the test object first became visible. Reese[30] repeated this work using monocular instead of binocular observation and found an average difference of 1.00 D. He found, in addition, that this difference vanished when atropine was instilled in the eye under test. Later, Reese and Fry[31] determined the state of accommodation on 12 subjects who were increasingly fogged with plus lenses. Some subjects revealed an apparent myopia as blur increased, but others showed no change, and one subject demonstrated a change toward hypermetropia. This kind of individual variability was also found in several investigations of nocturnal myopia.[9, 14, 32]

Whiteside[33] has recently measured the refractive state of a number of subjects as they observed a "bright and empty visual field" (a large, diffuse light source). He found that the eyes adopted a relatively myopic state of an amount (1.16 D.) comparable to values which have been reported for nocturnal myopia, but his results were conceivably biased in the myopic direction, since each subject was required to observe a near object (12-18 inches away) prior to each trial.

This—shall we say—"bright myopia" closely resembles the unexplained accommodative portion of night myopia, but obviously can-

not be a result of a changeover from photopic to scotopic illumination levels. Instead, the evident factor common to both situations is the absence of resolvable detail in the visual field. In the one case, detail was purposely removed from the field; in the other case the loss of resolvable detail was a consequence of the decreased visual acuity which accompanies decreased illumination. In either case, changes of accommodation became pointless since the appearance of the field could scarcely be altered by even very large changes of accommodation, so accommodation presumably assumed a "resting" position, or a position of "vantage" or "poise," which corresponded to about a diopter of increased refractive power.

In a previous paper[34] it was reported that totally color blind subjects failed to respond to changes in the stimulus to accommodation but instead maintained a relatively fixed "myopic" state as the stimulus was altered. The subjects all had low (20/200) visual acuities, which is characteristic of typical total color blindness. For these subjects too, then, changes of accommodation would have been of little benefit since maximum or nearly-maximum resolution could be achieved for targets at any distance *without* changing accommodation, especially when a relatively myopic refraction was maintained.

The purpose of the present study was to investigate accommodative behavior as visual acuity was progressively lowered at photopic levels of illumination, thereby examining the possibility that the effects of nocturnal myopia are due, not to the very low level of illumination at which the effects become evident, but to the pronounced decrease in visual acuity which inevitably accompanies such a reduction of illumination. Accordingly, the accommodative responses of six normal observers were determined over a stimulus range of several diopters with progressively blurred targets which, at photopic levels of illumination, simulated a progressive decrease in visual acuity.

APPARATUS AND PROCEDURES

The basic apparatus and the methods of presenting the targets, altering the stimulus to accommodation, recording and measuring the refractive state of the eye (the accommodative response), have been described in a previous paper.[34] The basic instrument was an automatic recording haploscope equipped with a subjective coincidence optometer to determine the refraction of the tested eye. A Badal optometer system containing a reduced Snellen chart permitted continuous alteration of the stimulus to accommodation from 0 to 6.25 D. The Badal optometer could be removed to allow observation of targets placed at various dis-

tances, or the stimulus could also be changed by viewing a fixed target through plus and minus lenses.

Stimuli were usually presented in increasing order, that is, beginning with a zero stimulus value, the dioptric magnitude of the stimulus was increased in 0.50 or 1.00 D. steps to a maximum value of 6.00 D. Changing the order of presentation had little effect on normal observers except when the target was blurred to a considerable degree. Under these conditions a series of decreasing stimuli revealed a slowness or "reluctance" to relax accommodation, similar to that found by Whiteside[33] and also noted under certain conditions by Fincham.[35, 36]

Blurring of targets

With photopic targets, three methods were used to simulate a progressive decrease in visual acuity. All methods consisted of progressively blurring the target, enabling the observer to resolve only larger and larger detail.

(1) Convex lenses of sufficient powers, placed in the lens cells of the haploscope, blurred the target by optically placing it beyond the far point of the observer's eye. This method, similar to that used by Reese and Fry, was of only limited usefulness since, of course, it fixed the value of the accommodative stimulus, i.e., the accommodative stimulus value could not be changed without also changing the blurredness of the target.

(2) A series of lacquered lenses was prepared and each lens was masked to expose only its most homogeneous area about 1.5 x 2 cm. in size. Placing these lenses singly or in combinations just beyond the half-silvered mirrors of the haploscope blurred the stimulus without disturbing the appearance of the coincidence lines. This permitted a stepwise reduction of visual acuity which could be determined by reference to the Snellen target in the Badal optometer or the Snellen chart on the movable stand, whichever was in use. Since the coincidence lines were not similarly blurred, an accurate determination of the accommodative response could be made. In addition, this method offered the advantage of allowing changes of the accommodative stimulus by any of the three methods previously described without simultaneously altering the blurredness or reduction of visual acuity.

A possible objection to this method of blurring the target lies in Fincham's theory[35, 36] that the vergence of light at the retina is itself a direct stimulus to accommodation. Since the lacquered lens is simply an irregular surface which scatters and irregularly alters the vergence of light from the target, it is possible that a stimulus of unknown magnitude was introduced by the use of such lenses. For comparison, then, a

third method of blurring the target was devised which was not subject to this criticism.

(3) Thin ground glass plates were cut to fit over the reduced Snellen chart in the Badal optometer. Placed so, either singly or in multiples, the plates blurred the letters of the target quite satisfactorily, yet altered the vergence of light only to the extent that the ground surface nearest the observer was now effectively the target. Allowance for this displacement of the target (amounting to a maximum of 4 mm.) was made when setting a stimulus value on the Badal optometer.

SUBJECTS

Six male observers, ranging in age from 20 to 34 years, served as subjects. All had normal visual acuity (corrected), and all but one (DB) were experienced observers and familiar with haploscopic observations. Their optical corrections were placed in the lens cells of the haploscope.

RESULTS

The accommodative responses to blurred stimulus targets are presented graphically in Figure 1. The straight diagonal line in each graph is the "unit ratio line" and represents exact agreement between the focus of the observer's eye and the optical position of the stimulus target. Points above the line indicate over-accommodation; those below, under-accommodation. Each point shown represents the mean of at least three determinations. The amount of blurring of the stimulus is indicated by the visual acuity notation beside each curve, which refers to the smallest line of Snellen letters which could be read while that curve was being obtained.

With natural acuity, i.e., with no added blur, the experienced observers showed close agreement between stimulus and response over the whole range. The one inexperienced observer, DB, showed considerable under-accommodation for the higher stimulus values, which is common with subjects unaccustomed to haploscopic observations.

With blurred targets, two effects were noted: An increased accommodation at the lower stimulus levels, and a decreased response to the higher stimulus values. With maximum blur the subject could see only a shadow in the lighted field, and the essentially horizontal response curves in Figure 1 indicate an almost complete lack of response to changes in the stimulus value under these conditions. It is of interest that the final levels assumed by the accommodative mechanisms of all six observers ranged from about 0.50 to 1.75 D., averaging about 1.25 D., a value which agrees well with Whiteside's 1.16 D. for the "bright and empty visual field" and with values estimated for the presumptive accommodational portion of night myopia.

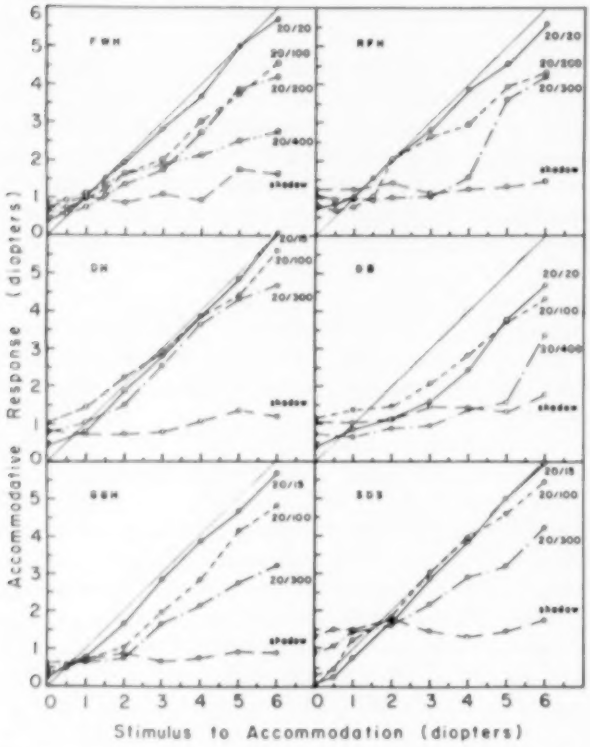

Fig. 1. Responses of six normal observers to accommodative stimuli. Targets were blurred to simulate a decrease in visual acuity. Notations beside each curve refer to the smallest line of Snellen letters read during that series.

The same data are replotted in Figure 2 to show more directly the effect of decreased visual acuity upon the accommodative responses. The effects previously noted are clearly evident here—a gradual increase of accommodation at the lowest stimulus levels as blur was increased, a pronounced decrease of response to the higher stimuli, and the final attainment (with maximum blurring) of a relatively fixed focus at an average value of about 1.25 D. This progressive decrease in the measurable amplitude of accommodation is exactly analogous to the "nocturnal presbyopia" encountered when illumination is progressively decreased.

When the target was blurred to a considerable degree, some observers exhibited an accommodative behavior which could be described as a "reluctance" to change accommodation, or as a tendency to maintain a particular state of accommodation despite stimulus changes of several

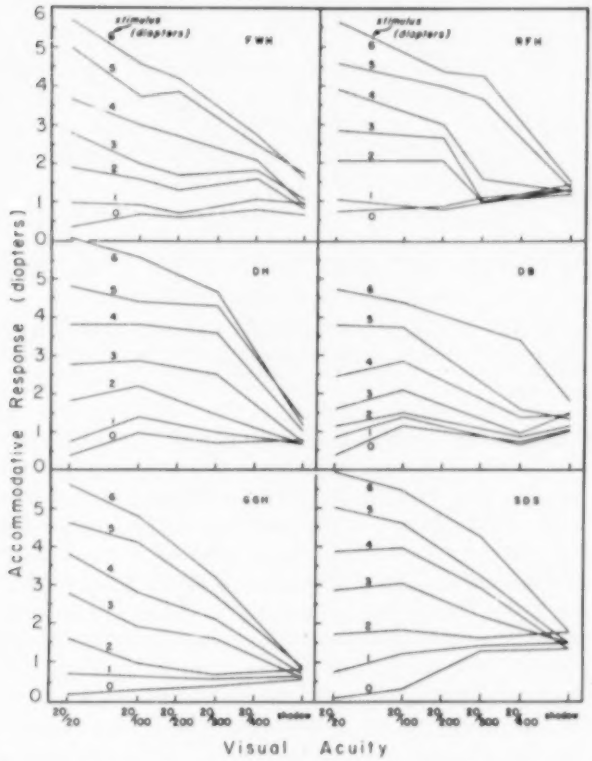

Fig. 2. Data of Fig. 1 replotted to show more directly the effects of decreased visual acuity on accommodative responses.

diopters. This tendency was emphasized when stimuli were presented in decreasing order immediately following the usual increasing series. Two examples are shown in Figure 3, where the order of presentation of stimuli is indicated by arrows. In each case, as the stimulus was increased in steps from 0 to 4 or 5 D., only small changes in the accommodative response were recorded. An additional 1 D. increase in the stimulus then evoked a sudden, large increase in accommodation. This increased accommodation persisted even when the stimulus value was subsequently decreased, resulting in a response curve considerably higher than the curve determined with increasing stimulus values. These observers, then, "relaxed" accommodation no more readily than they "stimulated" accommodation. Instead, they tended to maintain a given refractive state until a sufficiently large change of the stimulus "forced" a change in accommodation.

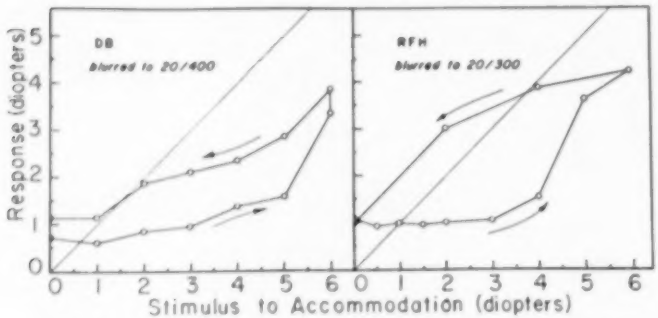

Fig. 3. "Reluctance" to change accommodation. Arrows indicate the order in which stimuli were presented. Subjects viewing blurred targets tended to maintain a state of accommodation until the stimulus was changed sufficiently to "force" a change in the refractive level.

In another experiment, target distance was varied and the responses of one observer (DH) were determined for two conditions of visual acuity. In these trials the dioptric value of the stimulus to accommodation was altered by changes in the physical distance of a large Snellen chart, rather than by solely optical changes such as those of the Badal optometer. Because the observer was aware of the distance of the target, even under blurred conditions, it was expected that his responses would correspond more closely to the stimulus values than they did when the Badal optometer was used. The results, presented in Figure 4, fulfilled this expectation with regard to the blurred target. When an unblurred target was presented however, a surprisingly large "lag" of accommodation (under-accommodation) was revealed for all but the lower stimulus

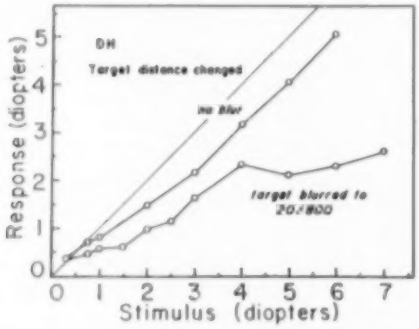

Fig. 4. Accommodative responses to blurred and to unblurred targets as target distance was varied.

values. The "lag" never exceeded 0.95 D. and remained approximately constant for stimuli greater than 2.00 D., which indicated that the observer did not find it necessary to accommodate fully or precisely for the target in order to resolve the smallest letters of the large Snellen chart. In certain respects, this situation was similar to that encountered when the Badal optometer target was blurred slightly to prevent resolution of the smaller lines of letters. It may be presumed in both cases that it was unnecessary to accommodate the full amount indicated by the stimulus value in order to see the target as clearly as possible. No significant improvement in the appearance of the target would have been achieved by more precise adjustment of accommodation so only minimal changes of accommodation were made. This, then, was a further demonstration of a "reluctance" to change accommodation, which is sometimes referred to as the "lazy lag of accommodation."

When extremely blurred targets were placed at various distances, responses showed closer agreement with stimulus values than when the Badal optometer was used under similarly blurred conditions. The improvement in response, however, was not large. Figure 4 shows that accommodative responses increased slowly as the blurred target was brought nearer, reaching a value of 2.30 D. for a 4.00 D. (25 cm.) stimulus. Targets placed closer than 25 cm. evoked no further changes in accommodation. Awareness of the distance of the target, then, assuredly influenced the responses of this observer, but fell far short of compensating for the blurredness of the target.

Results of another experiment, which employed accommodative stimuli ranging from —5.00 to +9.00 D are shown in Figure 5. The method consisted of fixing the Badal optometer at 0.00 D. and varying

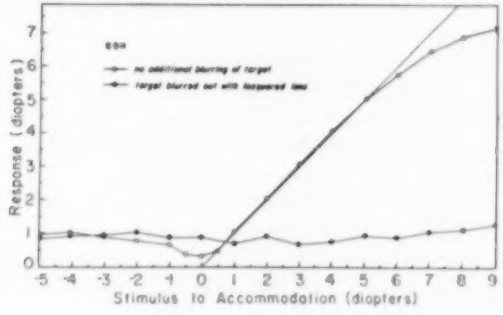

Fig. 5. Accommodative responses to a wide range of stimulus values. The d optric value of the stimulus was altered by placing convex or concave lenses before the eye while viewing the Snellen target of the Badal optometer at a fixed setting.

the stimulus value by placing convex or concave lenses of powers from +5.00 to —9.00 D. in the lens cells of the haploscope. The target, of course, was extremely blurred when the +5.00 D. lens was in place (a stimulus of —5.00 D.). It appeared progressively less blurred as weaker positive lenses were substituted. Maximum visual acuity (20/15) was attained through lenses ranging from 0.00 to —6.00 D., but acuity was slightly poorer when higher powers of negative lenses were employed. Responses were then determined again for the same range of stimulus values, but with ground glass plates placed over the chart in the Badal optometer to blur the target to a diffuse shadow. The latter series yielded responses which indicated a fixed ("presbyopic") refractive state of slightly less than 1.00 D. of "myopia" for all stimulus values. The former series showed this same refractive state for stimulus values from —5.00 to —3.00 D. The "myopia" decreased, however, as weaker positive lenses were substituted, until a minimum value of 0.32 D. was reached at a stimulus value of 0.00 D. In Figure 5 the effect appears as a dip of the response curve toward the base line. Responses showed very close agreement to stimulus values from 0.00 to 6.00 D., but fell off at higher values as the observer's amplitude of accommodation began to limit the responses.

DISCUSSION

The accommodative behavior observed in this investigation clearly indicate the existence of different "kinds" of accommodation or different "kinds" of accommodative stimuli. That is to say, in a given subject, quantitatively different accommodative responses to dioptrically equal stimuli occurred as stimulus conditions were altered. Certainly there is an appreciable difference between the myopic state found when the visual field is nearly devoid of resolvable detail, as with greatly blurred targets (or with greatly reduced illumination), and the state of accommodation found under normal photopic conditions with distant targets. A difference can also be seen in the responses to a target placed at various distances and the responses to a fixed but optically variable target. A detailed analysis of these different "kinds" of responses is offered in another paper[37] and will not be attempted here.

It was observed in the present study that as the stimulus target became progressively more blurred a progressive decrease in the measurable amplitude of accommodation resulted. Accommodative responses (i.e., the refractive state) to higher stimuli decreased, and responses to the lowest stimulus values increased, resulting finally in a relatively fixed focus of the eye under conditions of maximum blur. This behavior is exactly analogous to the "nocturnal presbyopia" found when illumi-

nation is progressively reduced. In addition, the value of the final "resting level" of accommodation found under these photopic conditions agrees well with the estimated amount of "nocturnal myopia" which cannot be accounted for by the aberrations of the eye, and which has been attributed to an actual change in accommodation.

These results support the idea that a change of accommodation does occur in nocturnal myopia, contributing perhaps as much as 1.00 to 1.25 D. of the total myopia found at very low luminance levels. More important, however, is the finding that the other phenomena associated with nocturnal myopia—the progressive decrease in the amplitude of accommodation and the final fixed focus resembling an absolute presbyopia—could be duplicated under photopic conditions by progressively impairing visual acuity. From this, it is evident that a basic factor underlying nocturnal myopia and nocturnal presbyopia is not so much the reduction of illumination, as the word "nocturnal" would imply, but rather the depression of visual acuity which inevitably accompanies such reduced illumination.

Although Fincham believes that reflex accommodation is stimulated by the vergence of light at the retina, the results of the present investigation stand opposed to such a view. Changes in the vergence of light caused only small changes or no changes at all in the accommodative state when blurred targets were used. Since blurring reduced reflex accommodation and finally eliminated it entirely, it seems likely that this type of accommodation is a response to the contrast gradients within the image, i.e., an adjustment of the accommodative mechanism to obtain and maintain an image with maximum contrast of the details at and near the fixation point. Blurring of the target, as in this study, reduces the gradients of contrast within the image and consequently reduces the stimulus to reflex accommodation.

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PHYSIOLOGICAL CONSIDERATIONS IN THE DEVELOPMENT OF ANOMALOUS RETINAL CORRESPONDENCE*

Phillip R. Haynes, First Lieutenant, M.S.C.†
U. S. Army Hospital
Fort Jackson, South Carolina

The study of binocular vision is concerned with the motor and sensory mechanisms of vision and their binocular integration and organization as well as with anomalies involving these mechanisms. The present paper is designed to point out certain physiological considerations in the development of retinal correspondence and the inconstancy of the objective angle of tropia and how these considerations are related to the determination of the disharmony between the motor anomaly and the sensory adaptation in cases of unharmonious anomalous retinal correspondence.

Corresponding points in the two retinas are defined as retinal elements which have identical visual direction.[1] This physiological definition known as Hering's Law of Visual Direction,[2] concerns itself with the functional organization of the visual apparatus. Corresponding points are determined by having the subject fixate a point, P, and then having him locate a series of points, P_n, which satisfy the above definition. The grid nonius technique of Ogle[3] and the binocular parallax technique of Fry[4] are the most suitable. A surface passing through these points is defined as the visual direction horopter (VDH). If the corresponding elements in the two eyes were symmetrically placed, the longitudinal horopter would be represented by a circle passing through the fixation point and the two entrance pupils. With this arrangement a given segment of the circle subtends equal visual angles at the two entrance pupils. This mathematical concept of the longitudinal horopter is termed the Vieth-Müller circle[5] (see Figure 1). Rotation of the Vieth-Müller circle (VMC) around an axis connecting the two entrance pupils results in a toric surface which represents the total horopter.

Figure 2 shows that if the axial length of the eye varied from A. $L._1$ to A. $L._2$, while the compactness of the retinal mosaic, P. D. and refractive properties of the eye remained constant, then the point P_1 would not stimulate the same corresponding points in the two cases.

*Submitted on February 3, 1956, for publication in the October, 1956, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.
†Optometry Officer, Fellow, American Academy of Optometry.

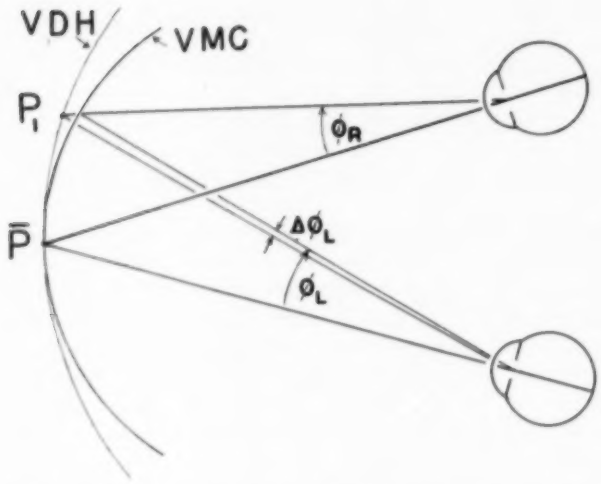

Fig. 1. The Horopter. The Longitudinal Visual Direction Horopter (V.D.H.) consists of the locus of points which have identical visual direction. The Vieth-Müller Circle (V.M.C.) consists of the locus of points determined when the included angles ϕ_L and ϕ_R are equal.

It is also theoretically possible to have the refracting power of the eye change while the P. D., axial length and compactness of the retinal mosaic remain constant. This would result in a change in the magnification properties of the eye which would result in a change in the retinal elements which are stimulated by a given point, P_n.

Assymmetrical distribution of the retinal elements on the two halves of the eyeball results in the visual direction horopter not coinciding with the Vieth-Müller circle.[6] (see Figure 1). This deviation from the Vieth-Müller circle is called the Hering-Hillebrand deviation.[7]

Changes in the fixation distance results in both eye movements and accommodation, and it is also possible that the contraction of the extraocular muscles result in certain distortions of the globe. These changes which occur with changes in accommodation are the most likely explanation for changes in the visual direction horopter which occur when it is measured for different distances.

Aniseikonia resulting from the spectacle correction of refractive anisometropia or the non-correction of axial anisometropia results in further changes in the configuration of the horopter.[8]

Another possibility is a change in the interpupillary distance which will result in changes in the configuration of the horopter. An increase

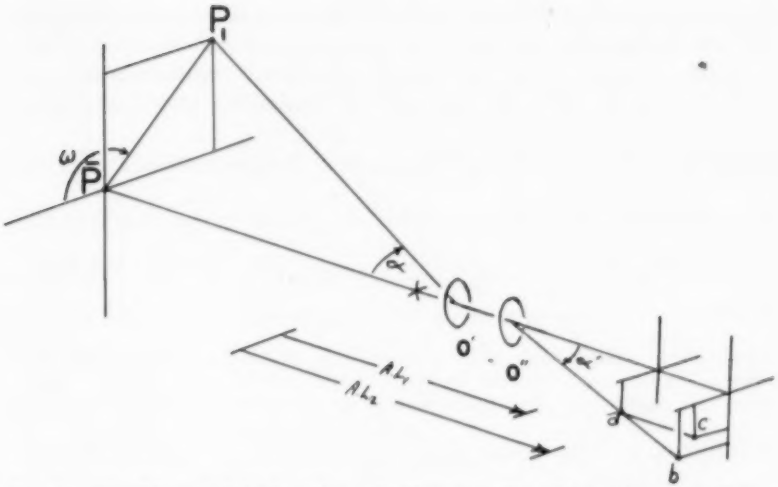

Fig. 2. The Effect of Axial Length on the Horopter. The object point, P_1, will not stimulate the same photoreceptors if the eye changes its axial length from A.L.1 to A.L.2, providing the optical magnification of the eye and the compactness of the retinal mosaic remain constant. The entrance and exit pupils are represented by O' and O''. The chief ray method is used to locate the image point and a and b represent the centers of the blur circles formed by the luminous point P_1 in the two cases. The retinal elements a and c are the same in the two cases.

in the P.D., providing all other factors remain constant, will result in a flattening of the horopter.

The above factors show that the configuration of the horopter in a normal individual is based upon the complex interrelationship between (a) growth factors which determine P.D., axial length, distribution of retinal elements, and refractive power of the eye, (b) physiological factors such as accommodation and eye movements and (c) aniseikonia. The end result from these changes in configuration of the horopter is that a given point P_n, fixed with respect to the point of fixation will stimulate different retinal elements as the subject passes through these various growth and physiological changes.

In the strabismic patient the two primary lines of sight do not intersect at the point of fixation and the images of the point of fixation do not fall on corresponding points, resulting in diplopia. In subjects with normal retinal correspondence, the angle of diplopia will be equal to the angle of squint which will vary for given distances of fixation as a function of the A. C. A. ratio and for a given distance as a function of its concomitancy. The present discussion will be limited to horizontal deviations.

The A. C. A. ratio[9-12] is defined as the amount of accommodative convergence brought into play by a unit of accommodation.* This ratio has a straight line relationship in a given individual and the A. C. A. ratio in adults is a constant. If the distance phoria were zero and the A. C. A. $= \frac{\bar{\sigma}}{U}$ where $\bar{\sigma}$ equals the convergence demand in prism diopters and $\bar{U}$ equals the accommodative distance in diopters, then the

*The average A.C.A. ratio in the adult[10] is 4.0 Δ. From the above definition it logically follows that in an adult the ratio is less than $\frac{\bar{\sigma}}{U}$ which means that the average subject becomes more exophoric as the point of fixation approaches the individual. The theoretical problem that arises is why did the central nervous system choose this ratio. The first consideration is that $\bar{\sigma}$ which is measured in prism diopters is equal to the equation $\bar{\sigma} = \frac{\text{(P.D. cm.)} \quad (100)}{\text{(u cm.} + 2.7)}$. Now it is a fact that the P.D. changes with age. Therefore a given individual would have to relearn a new ratio everytime his P.D. changed in order to have the motor system adapted to the convergence demand.

One could postulate that the A.C.A. ratio is learned and that since the child has a smaller P.D. and therefore a smaller convergence demand than that of an adult, then a lower A.C.A. ratio would be ideal for his binocular motor system. Thus, he learns this lower value which becomes imbedded into the central nervous system. The condition of ametropia introduces several theoretical problems with regards to how the A.C.A. ratio is learned. One explanation is that if one used a constant amount of fusional movement and his A.C.A. $= \frac{\bar{\sigma}}{U}$, then the subject would have a fast, efficient motor system. All other arrangements would have to incorporate a feed back system which would analize the binocular disparity and bring about a compensating fusional movement. This would result in a much slower system.

Now as his P.D. changes he has two alternatives. He could relearn a new A.C.A. ratio or compensate for the induced phoria by making motor fusional adjustments. From orthoptics results we know that the latter is much more subject to training. Therefore we could explain the above facts by stating that the average individual employs motor fusional movements instead of relearning a new A.C.A. ratio as the convergence demand changes due to a change in P.D. It is obvious that this theory does not explain the large deviations from the average that occur clinically. However, they could be pathologic variations caused by nervous system variations.

The concept that the A.C.A. ratio is learned has much opposition. Most authorities state that it cannot be altered by visual training. Hofstetter has shown that congenital squinters have an A.C.A. ratio which is constant and linear.[11] He has also shown that identical twins have similar A.C.A. ratios.[12]

However, the fact that the A.C.A. ratio remains relatively constant as a function of age implies that it is learned. This conclusion comes from the fact that the lens hardens as a function of age and therefore it would seem that it would require a greater amount of muscular contraction to bring about a unit of physical accommodation. If it takes more physiological accommodation to bring about a unit of physical accommodation, then the A.C.A. ratio should increase with age. However, it doesn't. Therefore, what maintains its constancy? Is it constantly being relearned to maintain its constancy?

eyes would always be pointed at the point of demand without compensating vergence movements having to be brought into play to correct for phoria deviations from the demand. Stated in another manner the subject would be orthophoric for all points of fixation.

Now if the A.C.A. $= \frac{\sigma}{U}$, then there would be a resultant phoria which changes as the point of fixation is moved nearer the subject. If the A.C.A. $> = \frac{\sigma}{U}$, then the subject will become increasingly esophoric for nearer fixation distances and conversely if the A.C.A. $< = \frac{\sigma}{U}$, the subject will become increasingly exophoric for nearer fixation distances.

The objective angle of squint for a given distance will vary as a function of myologic and refractive factors. They are as follows:

(a) *accommodative*—an increase or decrease in the accommodative convergence which occurs with changes in spectacle correction.

(b) *neurologic*—changes in neuromuscular relationship such as changes in the A.C.A. ratio or introduction of a paresis.

(c) *prismatic effect*—(refractive anisotropia) optical artefact induced from the prismatic effect in the peripheral portion of the spectacle correction.

(d) *changes in refractive error*—reduction of hyperopia resulting in a reduction in the amount of accommodative convergence.

(e) *changes in myo-global relationship*—growth factors can alter certain intra-orbital relationships.

(f) *changes in demand*—this is a function of the P.D.

(g) *surgery*.

The strabismic patient can adapt to his anomalous motor condition by making certain sensory adaptations. These adaptive mechanisms are:

(a) Alternately suppress one eye resulting in an essential or accidental alternator.[13]

(b) Monolateral suppression of the non-dominant eye resulting in a monolateral tropia.[14]

(c) Develop the blind spot mechanism.[15]

(d) Adapt a new retinal correspondence so that the images of the fixation point will fall on retinal elements which will again have identical visual directions.[16]

Let us assume that the squinter in question is a three-year-old child

who spontaneously developed a 30Δ accidental alternating esotropia which was non-paralytic in character. This squinter has a dominant right eye. Let us further assume that this uncorrected hyperope has an A.C.A. ratio of such a value that the angle of squint will remain constant for all distances of fixation. With this hypothetical arrangement the point of fixation will always stimulate the same retinal elements and the angle of diplopia would be constant. This stimulus set-up would be ideal for learning a new neurological pattern for retinal correspondence because the same visual pathways in the two eyes are always being stimulated by the target of regard. After a given period of "visual training" with normal environmental stimuli this young squinter develops a new binocular correspondence which is harmonious in character. The child is now sensorially adapted to his motor anomaly.

It logically follows that there would be small changes in the angle of squint as one changes his fixation from point to point. Theoretically there are three possible mechanisms to correct for these "motor pointing errors." (a) First, he could develop motor fusional movements, as is done in the normal individual.[17-20] (b) A second possibility is to have a different sensorial relationship for each angle of squint. (c) The third possibility would be a mechanism which would operate on the same basis as fixation disparity[21, 22] in the normal observer. One must remember that even though the child has sensorially adapted to his motor defect, the new corresponding regions are anatomically quite different. In fact they make an excellent anatomical basis for a "fixation disparity" mechanism. This same anatomical arrangement would also be advantageous in the sensorial adaptation to the motor defect.

From the above discussions it appears that squinters with an A.C.A. ratio which allows the objective angle of squint to remain constant have the most ideal stimulus arrangement to develop another retinal correspondence. Conversely it would follow that patients with a low or high A.C.A. ratio or with extreme non-comitancy have a poor stimulus situation to become sensorially adapted to the motor anomaly. The value of the A.C.A. ratio could be an important factor in determining the type of sensory adaptation that would take place.

Now that the subject has harmonious anomalous retinal correspondence, what factors could alter this adaptation mechanism? If there is any change in the angle of squint it means that the anomalous retinal correspondence will be unharmonious in character. It is also possible that the same factors which alter the configuration of the horopter in the normal individual could result in a displacement of retinal elements normally stimulated by the point of regard, thus resulting in an un-

harmonious anomalous retinal correspondence. With such changes it means that either the subject will be unharmonious, compensate the new error with fusional movements, suppress or relearn a new neurological pattern to get back in harmony.

In my opinion it would be almost impossible to keep continuing to relearn a new neurological pattern every time there was a change to the unharmonious pattern.* It is also true that the central nervous system is much more adaptable in the young to take over functions formerly carried out by centers which have become pathologic than it is in older individuals. Thus, the central nervous system will not be able to correct for the changes which occur in the older individual which are due to high growth rates and spectacle corrections.

Now, let us consider the subject whose A.C.A $= \frac{\sigma}{U} = k$, and who develops a harmonious anomalous retinal correspondence. As he grows older there will be a need for the A.C.A. ratio to increase to compensate for the increase in P.D. so that the sensorial adaptation will remain harmonious. However, if the A.C.A. ratio remains constant, there is only one theoretical distance where the A.R.C. will be harmonious and at all other distances it will be unharmonious.**

Another possibility is that the fixation distance during play and normal behavior was fairly constant allowing the child to learn a harmonious anomalous retinal correspondence at near where he normally plays.[24] Since we employ testing situation distances of twenty feet, then obviously the correspondence would not be in harmony for the distance motor anomaly.***

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*The author has had the opportunity to study the development of A.R.C. in one five-year-old child. She was a 35° right monolateral esotrope with a 27° angle of anomaly measured by Lancaster Red-Green projectors. The A.R.C. was broken down by visual training and patching and surgery was performed to give the eye a better mechanical position. Visual training was held off for six weeks and when she came in for examination she manifested 11° of right monolateral esotropia which was harmonious on the Tschermak-Congruence Test. This A.R.C. was easily broken down by visual training and patching. It is interesting to note that the A.C.A. $\cong \frac{\sigma}{U}$

**Assuming that there is no change in correspondence for different distances and that there are no fusional movements.

***Assuming that the A.C.A. $\cong \frac{\sigma}{U}$.

Figure 3 shows how an unharmonious anomalous retinal correspondence develops in a case where the angle of squint remained constant but there was an increase in axial length.

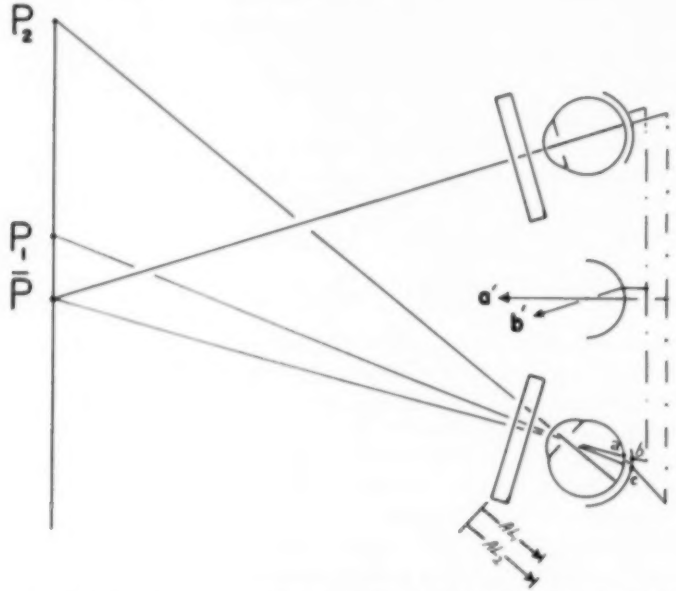

Fig. 3. The Effect of Axial Length on Harmony. A red filter is placed over the right eye and a green filter over the left. With this optical arrangement one can stimulate the two eyes independently of each other. In case one (A.L.1) the subject is sensorially adapted to his motor anomaly and if one placed a red and a green light at P, they would be seen as vertically aligned, both being projected in the direction a'. In case two, the axial length has increased from A.L.1 to A.L.2 with the magnification of the eye, correspondence and compactness of the retinal mosaic remaining constant. Now if one places a white light at P, the subject will have diplopia, the red image being seen in the direction a' and the green image in the direction b'. This is due to the fact that the chief ray from P to the left eye does not intersect retinal elements with the same visual direction in the two cases (i.e., retinal element b does not have the same visual direction as a, but a and c have the same visual direction. Now if one places a red light at P and a green light at P_1, the subject will perceive the two lights in the same visual direction, a'. If one employs the after image technique of Hering and Bielchowsky to measure the angle of anomaly, it will be found to be equal in the two cases. This angle of anomaly will also be equal to that determined in case one which was determined by measuring the subjective angle of squint. However, these three findings will not be equal to the angle of anomaly in case two which was determined by measuring the subjective angle of squint. This analysis points out one explanation for the clinical discrepancies between the two findings.

Another consideration in the discussions on the subject of harmony concerns itself with the testing procedures used in the determination of the objective angle of squint, the subjective angle of squint and the angle

of anomaly. Haploscopic procedures induce a psychic convergence[25] artefact which changes both the objective and the subjective angle towards less exotropia or more esotropia. Thus, if an esotrope with harmonious anomalous retinal correspondence was measured on a haploscope and psychic convergence was brought into play, the subjective angle would be eso. This would be interpreted as a sub-harmonious anomalous retinal correspondence.

The Hering-Bielchowsky After Image Test[26] is quite removed from normal environmental stimuli. It is to be noted that the after image test concerns itself with retinal areas which are not normally stimulated by the point of regard.[27] The author feels that tests should be employed which are closely akin to the ordinary conditions of seeing. The Tschermak Congruence Test[28] or tests based on this principle fulfill this condition.

Another consideration is that unharmonious anomalous retinal correspondence may be converted into the harmonious type by motor fusional movements. Therefore procedures which mask or eliminate fusion stimuli may mask the true type of A.R.C.

Many authors[29-32] state that unharmonious anomalous retinal correspondence is due to either inadequate or excessive sensory change with respect to the deviation. They fail to take into account the physiological considerations discussed in this paper and treat the whole problem as if the patient learned the wrong sensorial adaptation to his motor defect.

In my opinion the most plausable explanation for anomalous retinal correspondence is the development of harmonious anomalous retinal correspondence which is modified by the above physiological and anatomical factors which convert it to an unharmonious adaptation.

SUMMARY

The author discusses the physiological principles which must be considered in the development of harmonious anomalous retinal correspondence. The theory is further expanded to show how normal physiological and anatomical changes can convert a harmonious anomalous retinal correspondence into the unharmonious form.

An interesting theoretical and clinical consideration is what factors determine the sensory adaptation that a squinter will make to his motor anomaly. The main factors to be considered are age of onset, ocular dominance, A.C.A ratio, V.A., anisometropia, concomitancy and the angle of squint.

The author advances the following hypothetical analysis to account for the type of sensory adaptation to the motor defect (see Table I). It must be noted that the evaluation of anisometropia in such a table

TABLE I

TYPE OF STRABISMUS	MAIN DETERMINANTS
Alternating Tropia With Normal Retinal Correspondence	1. Equality of V.A 2. Little or no Anisometropia 3. Lack of ocular dominance 4. Low or high A.C.A. ratio 5. Tropia which occurs in subjects over age 5 6. Anisometropia where subject uses hyperopic eye for distance fixation and myopic eye for near fixation.
Monolateral Tropia With Normal Retinal Correspondence	1. Inequality of V.A 2. Anisometropia 3. Extreme ocular dominance 4. Low or high A.C.A 5. Inconcomitancy
Tropia With Anomalous Retinal Correspondence	1. A.C.A. ratio suited to maintain a constant angle of squint for all distances of fixation. $\therefore$ A.C.A. $= \frac{\sigma}{U}$ 2. Concomitancy 3. Little or no anisometropia 4. Extreme ocular dominance for monolateral cases 5. Angle of squint under 35° 6. Tropia occurring before age 5.
Blind Spot Syndrome	1. Esotropia of 13° to 18° magnitude 2. A.C.A. ratio suited to maintain a constant angle of squint for normal distances of fixation. (Within the limits of 13 and 18 degrees.)

is difficult because one cannot differentiate between congenital and developmental anisometropia.

The above theory suggests that:[33]

(a) A statistical study be made correlating the relationship between the A.C.A. ratio and the type of sensory adaptation.*

(b) Further investigation be made in the design of techniques for diagnosing A.R.C. The author recommends a flicker attachment to the Tschermak Congruence apparatus. This would help eliminate the suppression problem due to the fact that suppression has a certain latent period. This apparatus also does not eliminate fusion stimuli.

(c) Further investigations be carried on concerning fusional phenomena in A.R.C.

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*In considerable part this has been done, by Merton C. Flom. Variations in Convergence and Accommodation Induced by Successive Spherical Lens Additions With Distance Fixation—An Investigation. With the Description of a Clinical Method for Testing the validity of the Refractive Correction. Am. J. Optom. & Arch. Am. Acad. Optom. 32, 3, 111-136, 1955.

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AMERICAN ACADEMY OF OPTOMETRY

NEW MEMBERS

The following optometrists have been elected to Fellowship in the American Academy of Optometry. The Executive Council welcomes these new members.

Lt. Robert S. Arner, 240 Foulois Drive, Loring Air Force Base, Limestone, Maine.

Mr. Maurice Arthur Ashton, 49 High St., Ross-on-Wye, Herefordshire, England.

Dr. William Howard Avison, R.O., 58 Brant Ave., Brantford, Ontario, Canada.

Lt. John H. Carter, E.E.N. & T. Clinic, USAF Hospital, Scott Air Force Base, Illinois.

Lt. Irving L. Dunsky, USAF, 2750 U.S.A.F. Hospital, WPAFB, Dayton, Ohio.

Dr. Marion K. Eakin, 6009 West Blvd., Los Angeles, California.

Dr. R. W. Gilbert, 165 E. Highland Ave., Elgin, Illinois.

Dr. Theodore P. Grosvenor, College of Optometry, University of Houston, Houston, Texas.

Dr. L. Gerald Leonard, 2136 Lowry Ave. No., Minneapolis, Minnesota.

Ens. Earl F. Miller, II., School of Aviation Medicine, Naval Air Station, Pensacola, Florida.

Dr. Raymond F. Parker, 5416 College Ave., Indianapolis, Indiana.

Mr. Laurence P. Pelly, 9-b, Abbey St., Dublin, Ireland.

Dr. Victor H. Small, R.O., Yorkton, Saskatchewan, Canada.

Dr. Edward Tamler, 2351 Clay St., San Francisco, California.

Dr. Raymond P. Taub, 53 W. Main St., Somerville, New Jersey.

Comdr. Ralph L. Vasa, MSC, U. S. N., 3903 Morrell Court, Kensington, Maryland.

APERTURE ORTHOPTICS FOR THE NON-STRABISMIC*

Bernard E. Vodnoy†
South Bend, Indiana

INTRODUCTION

Aperture orthoptics may be defined as the practice of visual training through the use of apertures (instead of prisms, mirrors, red-green or polaroid lenses, etc.): the visual fields are thereby separated and by varying the position, the number of apertures, and the target separation, the various skills of binocular vision may be trained.

THE FOUR BASIC TECHNIQUES OF APERTURE ORTHOPTICS

In this article the writer will describe four main basic exercises which comprise aperture non-strabismic orthoptics. They fill the needs of 90 per cent or more of these patients. They are: Primary (1) Prism base-out through the single aperture; (2) prism base-in through the double aperture. Supplemental (3) Suppression elimination exercises with no prismatic effect; (4) physiological diplopia exercises.

INSTRUMENTATION

The instrument is constructed as follows (Figure 1): (a) A rule,

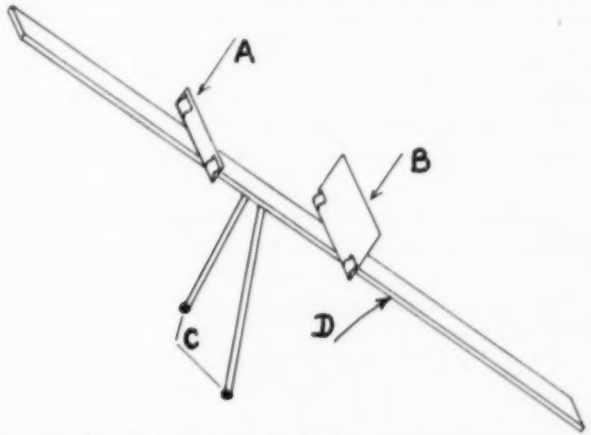

Fig. 1. Construction of instrument. A. Holder for aperture cards. B. Holder for targets. C. Rubber tipped legs to prevent slipping. D. Calibrated rule.

*Read before the annual meeting of the American Academy of Optometry, Chicago, Illinois, December 12, 1955. For publication in the October, 1956, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

†Optometrist. Fellow, American Academy of Optometry.

calibrated in prism diopters of convergence and diopters of accommodation. (b) A ¼" spring aluminum card holder for holding aperture cards. (c) A 2½" spring aluminum card holder to hold target cards. (d) A steel wire base which can slide up and down the rule and thereby make the instrument easily adjustable for height. Figure 2 illustrates the all-metal instrument. A similar model, made of less costly materials, is supplied to the patient for home use.

Fig. 2. Office training instrument.

PURPOSES

The purposes of the development and use of aperture orthoptics are as follows:

1. To fulfill the basic principle of all training, i. e., to make elements of the training procedure similar to elements experienced in everyday use.

2. To eliminate artificial effects, and use true distances to insure the transference of the skills learned in the orthoptic exercise to everyday use.

3. To elicit proprioceptive responses in the orthoptic techniques described in this report.

4. To expose the patient's face and eyes so that they can be observed during the exercise or test.

5. To provide targets which are free of distortion and aberration, whether the target is in the lowest or highest prism power position.

6. To provide easily understood goals to stimulate incentive.

7. To provide a method of showing the patient's improvement.

8. To measure gains in terms patient will understand.

PRISM BASE-OUT AND BASE-IN TARGET CARDS

The design of the prism base-out and base-in target cards is shown in Figure 3. The number of the card indicates the separation of the centers of the targets measured in centimeters. For prism base-out, 12 cards are used. For prism base-in, usually seven cards are used. The suppression controls in the left target are the ball and the words "into one"; in the right target, they are the cross and the word "fuse." Line targets are used to provide more accurate control on accommodation. All of these target cards are placed at the 15.00Δ position, approximately 16 inches on the rule.

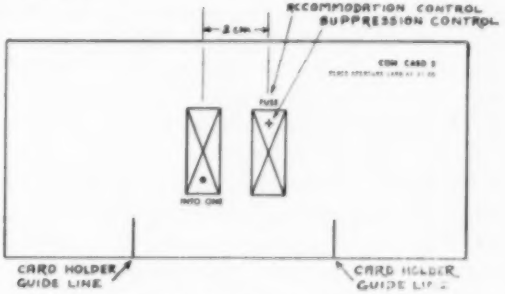

Fig. 3. Prism training card.

APERTURE CARDS

A single aperture card is used for prism base-out training. A double aperture card is used for prism base-in, physiological diplopia and suppression elimination training.

THE TRAINING POSTURES

The normal reading posture is used for all cases of exophoria and moderate cases of esophoria. The patient is seated with his arms resting on a table, the height is adjusted so that the end of the training rule, which is rounded for comfort, is against the upper lip, and the eyes are turned down as they would be at the patient's normal desk or near work.

The elevated position is used in severe cases, above 6Δ prism diopters, of esophoria. Here it is helpful to first train with the rule held and turned upward approximately 15 degrees above the horizontal, to utilize the natural association of elevation and divergence with mental effort.

The primary position, with the rule horizontal, is used in the moderate and severe cases of esophoria to precede the normal reading position, which is the final training position for these cases.

PRISM BASE-OUT TRAINING

The exophoric patient is administered prism base-out training as follows: Looking through the single aperture with the right eye the patient will see the target with the ball. With the left eye the patient will see the target with the cross. Looking with both eyes the two targets will fuse into one. The cross and ball should be present at all times.

If the patient cannot fuse, a pointer is held in the opening and the patient is urged to concentrate on the tip. If the patient still cannot fuse, another training card is held behind the aperture card, and have the patient concentrate on the pointer tip, and then raise cover card momentarily to achieve fusion. Keep increasing the exposure period until the examiner can dispose of the cover card and the pointer. In those cases where the patient still cannot fuse, start with the double aperture card and the lowest numbered target card and work back until the patient can fuse with the single aperture. Once fusion can be accomplished, have the patient alternate by looking over the target card, at the floor, and then back through the opening, regaining fusion each time and holding it until it is clear and single. Then change to the next higher numbered card as quickly as progress permits. The aperture card moves forward each time the target card is increased. Keep all target cards at 15.00Δ prism diopters. These training periods are continued until card 12 is mastered. This card has a 12 cm. separation. The usual exercise time is 20 to 45 minutes per day, divided into two or more sessions. The patient will use a home model instrument for daily training sessions at home. After he concludes his training he then repeats the training routine once each month to guard against regression. In this orthoptic program if fusion is accomplished, the visual axes cross at the aperture ahead of the target card. If the targets are in focus, accommodation is behind the aperture upon the target card at 15.00Δ or 2.50 D. Therefore, there is created the effect of base-out prism. The distance between the cards is an actual demonstration of the play between accommodation and positive convergence, and is the measure of the prism base-out effect.

PRISM BASE-IN TRAINING

The esophoric patient is given prism base-in training as follows: Looking through the double aperture card with left eye the patient will see the target with the ball. With the right eye the patient will see the target with the cross. With both eyes these should fuse. If the patient cannot fuse the targets with the double aperture card, make a hole in the rule at 12.00Δ and insert a pointer into the hole. Then have the patient look just above the target card and concentrate on the

pointer; the targets should fuse in the lower indirect field. The patient is then instructed to view the targets and practice holding fusion by direct vision. For a card with targets at 2 cm. separation, insert the pointer in the rule at 9.00Δ. If the patient still cannot fuse the first target card, start with a single aperture card and lowest numbered target card the patient can fuse, and work back until the patient can fuse the first target card with the double aperture. Once fusion can be accomplished, alternate by looking over the target card at the floor and back through the opening, regaining fusion each time and holding it until it is clear and single. This should be continued until target card 7 is mastered. Again the exercise time is 20 to 45 minutes per day divided into two or more sessions. In this orthoptic program if fusion is accomplished, the visual axes meet behind the target cards. The wider the separation of targets, the further back is the point of crossing. If the target is also clear, accommodation is at 15.00Δ or 2.50 D. Therefore, there is created the effect of prism base-in. The distance between the target card and the pointer is an actual demonstration of play between accommodation and negative convergence, and is the measure of prism base-in effect.

TABLE OF PRISMATIC EFFECTS

This table indicates that each successive card creates an increased prismatic effect of approximately 3Δ. The number of the card indicates the distance, in centimeters, between the centers of the targets.

Target Card No.	Position of the Aperture Cards in Prism Diopters	Target Card No.	Position of the Aperture Cards in Prism Diopters
1	19.50	7	36.00
2	21.00	8	39.00
3	24.00	9	42.00
4	27.00	10	45.00
5	30.00	11	48.00
6	33.00	12	51.00

Note: With target cards at 15.00Δ, the approximate prismatic effect is obtained by multiplying the number of the target card by 3; placement of aperture card is obtained by adding the amount to 15.00Δ

PHYSIOLOGICAL DIPLOPIA TESTING AND TRAINING

Every orthoptic case should be tested for physiological diplopia. Frequently, one finds in the more severe cases, homonymous, or heteronymous diplopia. The following exercise helps to eliminate suppression in the paramacular field, and builds fusion recoveries. Have the patient alternate fixation slowly back and forth from ball to star, making sure that the fixation object is single and the other target card, seen indirectly, is double. When the patient can do this easily, move the ball card forward to the next number on the rule. Do not move the star card. Continue moving the ball forward, approximately one inch

each training period, until the ball is at 60.00Δ. Keep the star card in far holder at 12.00Δ. Keep the patient's convergence on the ball, insuring that the star remains double. Slide the ball back and forth trying to come as close as possible, maintaining one ball and two stars. Training should continue until the patient's near point of convergence is 60.00Δ. If one star disappears, it indicates that the patient is suppressing.

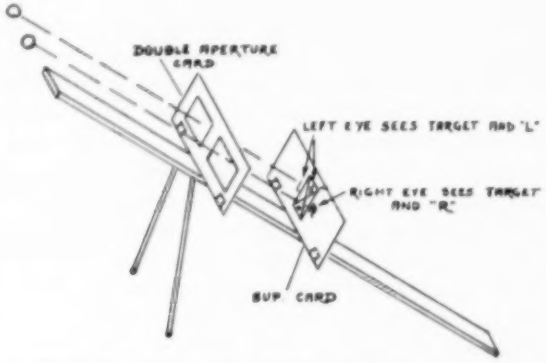

Fig. 4. Arrangement for cards and targets for suppression training.

SUPPRESSION-TESTING AND ELIMINATION

The target shown in Figure 4 is used as a supression test and exercise, and also as the pivot card, i.e., for fusion exercises with no prismatic effect. When going from prism base-out training to prism base-in training or from prism base-in to prism base-out, slide double aperture card backward or forward, until the patient sees the target and R with only the right eye, and the target and L only with the left eye. With both eyes open, the patient should see the target R and L. This is the test position. If either R or L disappears, or fades, the patient must practice until they are always present and equally clear.

Frequently in high heterophoria or periodic heteroptropia, where suppression is not deep-seated, constant diplopia will be experienced when the adjustment outlined in the preceding step is obtained. With cards adjusted as outlined, place a thumb tack in the rule right behind the aperture card holder. Slide the aperture card toward the patient until single vision is regained. Then slide the aperture card back and forth and determine the point at which diplopia occurs. Keep moving the card, back and forth, trying to move the diplopia point farther down the rule, until the tack can be touched and fusion held. When

fusion can be accomplished at the test position, alternate by looking over the target card at the floor and back at the card, regaining and holding fusion each time.

ADVANTAGES OF APERTURE TRAINING

The patient usually can understand the exercise, and how it may correct his problem, and be beneficial to him. The diagnosis the patient was given in exophoria, was that his eyes tend to diverge while reading (and/or while looking at the distance), therefore, he must strengthen his ability to turn his eyes *inward*. By making his eyes cross at the fixation card opening (which is progressively brought closer to his eyes with each succeeding card), he will be counteracting his tendency to turn the visual axis out. The patient can understand this and usually he will do his best to overcome it. The full set of convergence training cards are shown the patient and he is motivated to reach card 12.

The patient is given the instrument and the first two cards and an appointment to return in 10 days. He is told that if he can master them by the end of the 10-day period, he will be given the next two or three cards: by this method, he is given something to strive for, interest is maintained, and the next cards serve as rewards as his achievement level increases. When the patient looks at the distant object, accommodation and convergence are relaxed. When he looks at near, he accommodates 1.50 D. and converges ahead of the target. As he looks back and forth, he can feel the extra effort he must put forth to accomplish convergence. Normally, a person is not aware of his convergence. By raising the awareness of this function, the patient becomes aware of his deficiency and nature itself will tend to re-build the innervation and speed the patient's progress. By making the training distances, actual working distances, there is a good possibility the patient will transfer to his every-day tasks, the skills he acquires in his training.

The diagnosis the patient was given in esophoria was that his eyes tend to over-converge while reading, or tend to turn in. When he looks through the double aperture, his problem is forcibly demonstrated to him, for he will have great difficulty maintaining fusion even on the beginning card. The acceptance and participation in a visual training program is thereby improved.

SUMMARY

A method of orthoptic training for the non-strabismic patient is presented in which apertures have been substituted for prisms, mirrors, lenses, red-green, or polaroid lenses, etc. The techniques outlined have been applied on several thousand patients by a number of optometrists. Because of the writer's experience of applying these techniques on several

hundred patients and the reports he has received from a great number of optometrists who have applied them, it seems evident that aperture orthoptics, as herein described, fulfills the requirement of a useful orthoptic technique.

801 NORTH MICHIGAN STREET
SOUTH BEND 1, INDIANA

CORRESPONDENCE

COMMENT ON RAMAZZINI AND INDUSTRIAL MEDICINE

To the Editor:

After re-reading your editorial[1] on Ramazzini, I recalled two references to him which may be of further interest to you and possibly to other readers of the AMERICAN JOURNAL OF OPTOMETRY.

The first is an oration, "Ramazzini Wasn't Certified," by James H. Steiner, M.D. This portrays the history of the long effort to attain board status for industrial medicine, an effort successfully culminating in 1955. The published statement is to be found in the JOURNAL OF INDUSTRIAL MEDICINE AND SURGERY, Vol. 25, No. 1, pp. 25-28, 1956.

The second is a reference to Paracelus—one Philip Theophrastus Bombastus von Hohenheim—who long bore the stigma of being medicine's all-time, most notorious quack. He has now emerged as one of the best medical minds of remoter centuries, one who broke off the shackles of Galenic medicine, and, in a measure, was the true father of industrial medicine, antedating Ramazzini by nearly two centuries. *cf.* JOURNAL OF INDUSTRIAL MEDICINE AND SURGERY, Vol. 25, No. 3, p. 139, 1956.

An interesting subject, this!

RICHARD FEINBERG, O.D., PH.D.

TITMUS OPTICAL COMPANY
PETERSBURG, VIRGINIA.

[1]Carel C. Koch. Ramazzini and Industrial Health Studies. Am. J. Optom. & Arch. Am. Acad. Optom. 33.8 423-424. 1956.

DEVELOPMENTS IN CLINICAL OPTOMETRY*

Eric Bateman†
Henley-on-Thames, England

PURPOSE

The purpose of this paper is to suggest to those interested in the science of optometry that it is now necessary to consider visual problem causes and effects in a more detailed physical and psychological sense than has heretofore been deemed necessary. Attention is drawn to the fact that the correction of ophthalmic functional defects and anomalies are defined legally in many countries as the "practice of Optometry" and the practitioners who apply the science are known as optometrists.

By implication we suggest that a vast program of development, health-wise, social, educational, and political, lies before the builders of this profession, on a world-wide front.

INTRODUCTION

It is convenient to consider that the *science* of refraction dates from 1863, with the publication of Donders' *Acccommodation of the Eye*. This was soon followed by the works of Landolt and others. The crystallized knowledge of the fathers of refraction formed the basis of ophthalmic optics as practiced by the oculists and optometrists of the later 19th century. From 1860 to 1930, broadly, we might state that the science of refraction was in the "formation stage." This was due to the fact that no new approaches or techniques of importance were developed. In the English-speaking countries at any rate, approximately 75 per cent of all members of society who had their eyes examined, consulted an optometrist for this purpose. Thus, during the last century two groups of practictioners have been handling this work.

To some extent it must be conceded that both groups were slow to develop the science and art beyond what we might denote as "the Donders stage" for the following reasons: The approach of the eye-physicians to the subject was conditioned by the outlook of the medical schools, which, for hundreds of years had been conditioned by the Aristotelian concept of medicine. In consequence they tended to undervalue the importance of correcting functional anomalies and the importance to health of visual anomalies demanding very exact techniques.

*An abridgment of the material presented before the German Optometric Congress, Baden-Baden, Germany, May 8, 1956. Submitted on May 28, 1956, for publication in the October, 1956, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.
†Optometrist. Fellow, American Academy of Optometry.

The optometrists, on the other hand, were handicapped for different reasons. First, they were late in developing a sense of their mission in seeing themselves as the pioneers of a vital public professional service. Second, they were handicapped at the start because of the lack of schools, colleges and hospitals suitable to develop a new professional group capable of applying the highly specialized techniques, which later became available. For too long the optometrist tended to consider and interpret in terms of physical science and to ignore the many psychological aspects of vision impinging on physiological optics, which today have a very real bearing on many clinical problems of everyday practice.

We are here considering evolutionary tendencies, so that in mentioning dates we do so as a matter of convenience to help us get the picture in its correct setting. In this sense we can say that during the last fifty years schools and colleges have arisen throughout Europe, the United States of America, Canada, and Australia, where academic and professional courses are available, leading in many cases to the attainment of a degree, such as Doctor of Optometry, Doctor of Ocular Science, Bachelor of Science in Optometry, with research degrees such as M.Sc. or Ph.D. for graduate work.

This means that the "ophthalmic optics" concept and approach to visual problems is gradually being superseded by "the optometry concept" and the new practictioners are defined, for the most part legally, as "optometrists." It is with a consideration of the ideology of refraction as practiced by an optometrist that we are here concerned. It will be seen that we lead up to a consideration of visual training, but we submit that all the techniques at his disposal are but part of a whole: the diagnosing, evaluating and correcting of visual malfunction in the interests of efficient, comfortable binocular vision.

THE IDEOLOGY

The eyes may be conveniently considered as parts and outposts of the central nervous system, and as such, neural energy is available to manipulate the binocular apparatus as to its convergence, accommodation and eye movements. If errors of adjustment or malfunction have developed, compensating energy is drawn from central sources. It is precisely because malfunction is common that the correction of the eyes by lenses often has a surprising effect on general health, owing to the fact that energy is often diverted elsewhere where it is more urgently required.

The paramount function of the eyes is to receive and interpret a single mental image of reality. Hence the mechanism which produces this is the primary function of binocular vision. This mechanism con-

trols ocular motility. So vital is a state of poise during the visual act that if for any reason a break-down occurs, one image is repressed and a functional blind area is produced of sufficient size to avoid diplopic images.

Accommodation is secondary to this primary function. This is another way of stating that a person may be prepared to accept blurred vision without obtaining professional advice, but under no circumstances will he tolerate double vision for a moment longer than is necessary to obtain such advice.

Refractive errors, as such, are now realized to be developmental variations from a norm. The purpose of lenses is not necessarily to correct an error of refraction, but also to insure that accommodation is correctly linked with convergence for all distances of use. Such linkage must carry with it, of course, the highest binocular acuity for the distance concerned, unless this is to be deliberately reduced for a particular purpose. The main overall consideration is to maintain the eyes in balance with the central nervous system in order to conserve the maximum amount of nervous or neural energy with the best possible vision. In our industrial civilization, where nearly all work is carried on in artificial surroundings, the correction of the eyes in this sense is vital.

From a consideration of these viewpoints it will be seen that the monocular approach to refractive error may very well correct the physical condition in a strictly static sense, but today we are more concerned with the whole binocular system in a dynamic sense, because a number of symptoms found today, develop under dynamic conditions.

In practice this approach may be applied in one of several ways: (1) The actual errors of refraction can be corrected by the monocular technique and subsequently modified under binocular conditions, or (2) The eyes may be corrected under binocular conditions, using Turville's technique, with or without supplementary techniques as initiated by Freeman. As a result of these tests a monocular addition may be indicated to balance actual ciliary adjustment in a physiological sense, and this may be considered an intrinsic part of the Turville technique.

But other considerations follow: (a) Binocular additions from 0.25 to 1.25 spheres can be accepted which increase visual acuity. The reason for this is that overconvergence for distance is further unlocked, and what might be designated the "cones of visual projection" fall more properly on the foveal centres on the one hand and the point of fixation on the other. It might be observed, however, that base-in treatment under conditions of full stereopsis will obtain the same result, that is, increased acuity, without drawing on negative relative accommodation.

(b) Monocular additions, and very occasionally, subtractions, to improve the quality of stereopsis are sometimes indicated. This is effected by a slight adjustment of image size which makes for improved fusion, and therefore stereopsis. (c) The need for a combination of either of the above with an added prism to correctly relate the entire situation with orthophoria for infinity and 4Δ of exophoria at the reading distance may be indicated. In other words, accommodation lags behind convergence at the near point, and although many consider the average amount is 6Δ, my own experience over the years is that 4Δ is nearer the true average.

Let us consider an example where the situation does not work out so neatly: Exophoria may be found at infinity with a condition of hyperopia or hyperopic astigmatism. This is a situation which must be corrected, for it seems to cause a waste of neural energy and to bring on fatigue. It should be corrected by base-in prisms. An esophoria for infinity is the "normal expected" for these defects inasmuch as the actual overcoming of various degrees of hyperopia tends to develop overconvergence. Thus, when fusional convergence, or more correctly, fusion, is broken down by the use of the Maddox rod, the eyes may converge. In the above example the visual acuity may be considerably raised by the introduction of the prism.

Again, in myopia, the "expected" for infinity is an exophoria, because no accommodation is normally in use for infinity and therefore there is no associated convergence tension, and the eye then tends to take the position of rest along the axis of the orbit. The quality of fusion and stereopsis is often of a low order in such cases. It may happen, however, that the unexpected occurs, and an esophoria is disclosed for infinity. If it is not structural, stereoscopic treatment may improve acuity and overcome the defect. If it is structural or if it is desired not to prescribe treatment, base-out prism, incorporated in the prescription, will stabilize the situation and often increases acuity.

The theory, first introduced by Swann that "phorias can be ignored providing the duction in the opposite direction is sufficient to cope with the condition" does not hold good without further qualification. One might just as well take the view that a hyperopic error of refraction can be ignored so long as the ciliary muscle can overcome the defect. By actual manipulation of the spectacle lens, the eyes of an otherwise normal patient should always be left orthophoric for distance. If this rule is not observed, retinal slip may appear at infinity and this is the first step to lowered acuity. Inefficiency caused by this condition is quite tiresome when it appears at distances short of infinity. True ortho-

phoria simply means perfect binocular poise, and to be perfect it should remain so within the entire binocular field, not only when the eyes are in the primary position. If fusional convergence or divergence is stretched by effort to overcome a heterophoria, perfection of balance and therefore of function is upset: the quality of stereopsis is effected by slip, and in more extreme cases acuity is lowered.

At any moment the binocular apparatus may be considered to be in a given state as a result of equal and opposite tensions, all of which may be explained in part at least in terms of simple mechanics. For example, there is a forward thrust upon the globe caused by the external musculature. All eye movements call into use the extrinsic muscles, the opposing force being the antagonists, and so forth. In myopia, the pupils of an uncorrected myope are usually entirely relaxed. This is because the ciliary muscle, in simple myopia, is relaxed. In consequence, it is useful to prescribe a tinted lens for the first prescription until such time as the accommodation-convergence relationship has become normal, when it will be found that the position of physiologic rest of the pupils has usually become modified. The tint can then be removed from subsequent prescriptions.

The balancing and adjusting we have so far considered concerns what we might call the mechanics of the subject, for we have regarded our problem in terms of physical adjustment in relation to an assumed fixed psychological fact: the innate desire of the mind to use two separate instruments in the interest of stereopscopic vision. May we assume that the actual quality of vision is also perfect, even if the acuity appears to be 100 per cent efficient? We will now consider this aspect of the matter in clinical terms.

Let it be conceded that the psychic desire to use two eyes for a single purpose must be considered innate. If this is so, why then do eyes become amblyopic? Why do they become amblyopic and develop squint? Why do the visual axis deviate without suffering amblyopia? Or why does acuity drop in one eye, sometimes in both, without apparent complication of squint or amblyopia? To answer these questions we must remember that anything that interferes with the normal flow of neural energy may tend to produce these conditions, or any problem effecting the retina itself could bring them on.

Having stated this, let me make this point clear: There are two classes of amblyopia, (a) due to physical local difficulties, and (b) due to strong psychic causes. Thus, for example, in motor paralysis of an extrinsic muscle, the movement of the eye would be impeded in at least one direction of gaze, and diplopia would result. This is where the

subconscious mind enters to solve an intolerable problem. It will start learning to suppress an unwanted image in the eye which it finds the easier to cope with in terms of the expenditure of neural energy. It is for this reason that the non-affected eye sometimes develops the amblyopia. We all occasionally suppress unwanted images. The normal example is that which occurs with the use of a monocular microscope. We learn to use one eye and to "ignore" the image seen by the other. Amblyopia is an extension of this principle. The reason is psychological in the same sense, too. In the one case we do not wish to see the bench or the instrument on it, and in the second case we do not wish to see anything with central vision at all! The only organic change which could take place as a result of non-use of central vision is this: Synapsial gaps in the neural pathway might, through lack of use "widen" sufficiently to introduce a physical obstacle in the early stages of treatment. This point, however, is by no means certain.

Because an amblyopia of this classification is psychological in origin it can be potentially cured in most cases, for every malfunction in this sense is potentially curable by re-education. But let us remember that having cured the amblyopia we shall have a case of double vision on our hands, and treatment of quite a different kind may be required to create binocular vision. Personally, I feel very doubtful if such a thing as "inherited" amblyopia exists at all. I am of the opinion that all are theoretically curable. In a very few years it should be possible to cure many deep level amblyopias under hypnosis and then follow with normal re-educative techniques. Essentially, alternating squint is outside the subject-matter of this discussion.

Let us now turn to lowered acuity without any apparent local motor reason. This can be monocular or binocular. We have made the point that perfection of stereoscopic vision depends on perfection of poise, and in the absence of the latter, "slip" often occurs. Slip is really an alternation of monocular perception in the first instance with minute objects. Over a period of time under conditions in which it is present, reduced acuity will result. Stereopsis, however, as such, will not be effected, only the quality of stereopsis will be altered. The latter point may be checked on the synoptiscope. If a pair of stereoscopic slides are observed first at simulated infinity and then blurred with a pair of +3.00 D. or 4.00 D. spherical lenses the images may be so blurred that their form is difficult to make out but there will be no difficulty at all in deciding which is the nearer or further "blur." The "slip" is entirely due to the high heterophoria or other tension, causing lack of poise.

In developing squint the first step in amblyopia is a small central repression. This is followed in time by a larger repression, and so on. The reason seems psychological. The visual mind is presented with an intolerable situation, which apparently demands constant central vision and alternating monocular vision at the same moment in time, or alternatively, central diplopia and paracentral binocular vision at one and the same time. It chooses the easier and suppresses the more difficult. This mechanism is the same as that of a neurosis. The difference is that more generally a neurosis is associated with emotional repression. But this is by no means always so. It is a fair statement, then, to affirm that amblyopia is a form of neurosis, and for reasons already given, is potentially curable.

We are now in a position to assess the technique to be adopted to correct errors of poise and the development of the highest quality stereopsis. We can do this by the use of prisms or by exercises which will gradually align the visual axis until perfection is reached. There can be no fixed rule. It depends on factors such as (1) the length of time the eyes have been developing the incorrect habit of fixation. (2) Whether the patient has ample innate energy or is just "getting by" with some stress. Age is therefore a contributing factor. (3) Whether any portion of the heterophoria is structural. (4) The time factor. In some cases of neglect, long re-educative treatment will probably be necessary: prisms to correct part of the phoria or tropia might reduce the time considerably. (5) The effect of prisms on the ultimate accommodation-convergence pattern. (6) The duction powers measured under stereopsis.

Broadly speaking, the writer feels that in cases of exophoria, the total adduction should be two and one-half times the amount of exophoria, and in cases of esophoria, three times the amount of esophoria, if treatment alone is to suffice. Thus, in a myope with 10Δ of exophoria for distance, the adduction should be 25 prism diopters. With adduction in this treatment work, it is important to measure only to the blur point and not the break. This is because accommodation tends to be brought into use until the final "break" position is reached. In the example just considered let us assume that instead of reaching 25 prism diopters we can only reach 20 prism diopters before the blur appears. Thus, we have 5 prism diopters to make up. We would therefore commence treatment with O.U. 2½ Δ base-in prisms in the patient's prescription, even if later on we reduced or removed the prisms. Let us assume, therefore, we have added the prism to the patient's prescription and that we are now ready for treatment. In the case we are following

a selection of photographic stereoscopic slides is used. These consist of pairs of photographs, each of which has its control mark. The patient has first to bring the two separate pictures at the top of the slide together, fusing the frames. If this cannot be done, prism base-out is supplied until the first pair of pictures in the slide of our series is fused. The rotary prism is then given vernier control until the "control cross" is perfect. The patient now knows what he should see. His attention is then drawn to the lower picture. He has, as it were, to go "down a step" and converge to fuse this picture. He may be able to do this by drawing on his own convergence power or he may require additional base-in prism. Finally fusion is achieved. After this has been done a few times he is made to achieve this step without additional help from the rotary prisms. Later, the initial prism setting is *reduced* so that the patient has even greater effort to secure the results. This process is repeated on the whole selection of slides, each slide being more difficult of achievement than its predecessor.

When ability to cope with all these convergence exercises has been achieved, we again make the process more difficult by increasing his exophoria with prisms and again going through the process with the slides. This treatment always must be undertaken at simulated infinity. One result of the treatment may be that the adduction has been increased, although this is a secondary result. We may find that our 10Δ of exophoria is now only 2Δ.

At this point the patient would be returned to the rotary prism stereoscope and large retinal awareness slides introduced. Varying degrees of stereopsis are intrinsic to the design of these slides and the patient can practice distance-to-near observation in a psychological sense with his actual accommodation completely static and controlled. After a course of these treatments he may receive a generalized base-out, base-down, base-up and base-in course of training under stereopsis. If he still has the 2Δ of exophoria this should be corrected by prism in the prescription, normally divided between each eye.

Whatever the initial condition as to poise, the first step is an analysis of the situation followed by treatment. It is vital that stereoscopic slides are used. "Fusion only" slides are of use, and then only briefly, in the intermediate stage of curing an actual squint. The reason for this is that as soon as the turning eye is brought to its correct position of poise, the visual axes exactly cross and stereopsis is instantly present. True, vision may be blurred, but when stereopsis can be achieved we can soon build up its quality.

Visual training should always be undertaken at simulated infinity

unless some problem actually effecting accommodation is involved. If the monocular accommodative ranges are normal for age prior to treatment and the relationship between the distance phoria to be corrected and the manifest heterophoria at the near point are correct, we can leave accommodation, as such, alone. Thus, in the case we are following where, before treatment the distance 'phoria is 10Δ exophoria, we should expect substantially 16Δ of exophoria at the near point. If the amplitudes are assessed as normal we can ignore accommodation as part of the problem.

Supposing, however, that ciliary amplitudes are low, in a functional sense, treatment can be given by the introduction of plus and minus lenses to the blur point. This can best be done in practice with a refracting unit. Our American colleagues have introduced a technique which they call "accommodative rock." This consists of the monocular introduction of plus and minus lenses before each eye in turn; commencing with +0.25 D. sphere before the right eye, and —0.25 D. sphere before the left, while the patient is fixing a target. Plus 0.50 and —0.50 is next introduced, and so on, until blur. The process is then repeated by putting the minus range before the right eye and the plus before the left. The patient is required to fixate monocularly. Because accommodation is yoked in the two eyes, then when plus lenses are placed before one eye both it and its fellow eye relax accommodation. Similarly, minus lens placed before an eye stimulates accommodation in both eyes. Accommodative rock, then, as customarily administered, consists of causing the patient to stimulate and relax accommodation, in both cases with convergence free to take its position free of fusion stimulus. It is therefore a calisthenic sort of exercise. Although there are a number of objections to this in terms of optics, inasmuch as image size-difference is introduced, monocular vision is quite possible for a considerable distance within the range developed, and accommodation is stimulated by this technique.

A clinical survey of optometry would not be complete without a brief look at the subject of "squint." This condition has been investigated at considerable length by a long line of able investigators. During the present century we might mention Worth, Maddox, Cantonnet, Giles, Gibson and Keith Lyle. The fundamentalist amongst this distinguished list of investigators was Cantonnet. It was he who drew attention to the fact that an infant is aware of color long before the rationalizing powers are developed which interprets form. His book, published in Great Britain in 1930, was translated by the late Max Coque and his teachings became the foundation upon which all subse-

quent teaching and treatment was built. It was he who introduced the important aid of using the accommodative-convergence link associated with the use of the will power of the patient to bring the squinting eye more nearly to its correct position. His technique was re-educative and therefore fundamental. In effect, after exact diagnosis as to the situation at the time of the first or early consultation, the patient is taken back in time to the point where the breakdown occurred, and re-educated from that point forward.

Here, I would like to add an observation of my own: The infant recognizes size and perhaps color. But if two or more colored objects are put before him he recognizes which is the nearer object and by implication the further. In other words, in an infant with normal vision, stereopsis is present when binocular fixation has developed. To a great degree this is also true regardless of the quality of the vision.

As soon as the area of amblyopia has been reduced or a false functional fovea disposed of by the usual treatment, stereoscopic slides should be used for training purposes regardless of the actual amount of physical deviation. Moreover, such slides, the writer believes, should be highly colored, and their subject-matter geared to the mental age of the young patient.

In general terms we can state that breakdowns in binocular vision (as we prefer to call them) are caused by physical, or if you prefer, mechanical causes in the case of infants and children. But in dealing with adolescents and young people who develop these conditions, a high proportion may well have psychological backgrounds. Co-operation with the psychiatrist is practically essential in such cases.

DIAL CLOSE, MARSH LOCK
WARGRAVE ROAD
HENLEY-ON-THAMES, ENGLAND.

A SIX GENERATION PEDIGREE OF CONGENITAL ZONULAR CATARACT*

Harry Jankiewicz† and Dale D. Freeberg‡
Los Angeles College of Optometry
Los Angeles, California

INTRODUCTION

Our College has been conducting visual screening surveys for the schools in the Los Angeles County School District and for local Parochial Schools. During the screening of third grade students at a Lutheran School, the retinoscopist and ophthalmoscopist observed that a seven-year-old girl had nuclear cataracts. A conference with this girl's mother and an examination of the three affected members in the local area resulted in the information collected on what is termed the "L Pedigree" of congenital cataract.

HISTORICAL REVIEW

Gates[1] believed that autosomal dominant, autosomal recessive, and X-linked recessive pedigrees of cataracts have been established. Furthermore, he stated that a pedigree of Dyer, which contained six affected males in four generations, might be Y-linked. However, too few child-bearing females were in the pedigree to assure such a conclusion. Likewise, the pedigree of Galezowski, which had seven affected females in four generations, he thought might be explained by attached X inheritance. Too few males, however, occurred to make this certain.

Sorsby[2] pointed out that congenital cataracts are nuclear or capsular, that cortical cataracts are postnatal, and that pre-senile cataracts are cortical or nuclear. Most inherited congenital cataract is transmitted as a simple dominant trait. Only a few autosomal recessive pedigrees have been described.

In a report on discoid cataract Rados[3] claimed that his and similar pedigrees of other investigators could all be explained by autosomal dominant inheritance. Lee and Benedict[4] studied a similar pedigree.

After a survey of the literature, Lutman and Neel[5] found that the pedigrees of Harman, Groenouw, and Waardenburg had a "uniform" type of specific cataract, whereas those of Knies, Gjersing, Halbertsma, Walsh, and Wegman had more than one type of cataract per pedigree.

THE L PEDIGREE OF CONGENITAL CATARACT

Ophthalmoscopic examination of the third grade girl mentioned in

*Submitted on April 28, 1956, for publication in the October, 1956, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.
†Ph.D., Member of faculty, Fellow, American Academy of Optometry.
‡Optometrist, Member of faculty.

the introduction revealed Centrad-Symbol-shaped nuclear cataracts. Since her uncorrected visual acuity was 20/50, she sat in the front row of her classroom. Slit-lamp examination by an ocular pathologist revealed zonular cataracts which affected the central and equatorial regions of the nucleus. She is the third individual in Generation V shown in Figure 1.

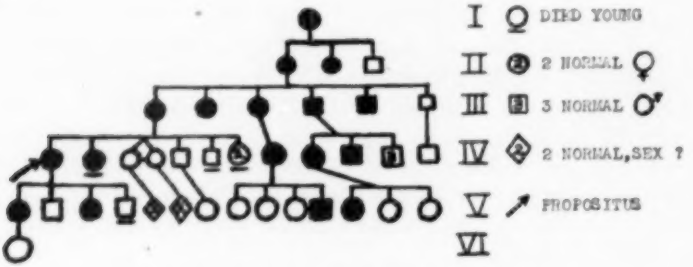

Fig. 1. I. Pedigree of congenital cataract.

Examination of this girl's older sister, the first individual in Gen. V, showed that she had similar cataracts. Her uncorrected visual acuity was 20/65 O.S. and 20/75 O.D. and corrected it was 20/60 and 20/70. Examination of her young daughter, the individual in Gen. VI, revealed that she was normal.

The mother of these affected sisters was examined with the slit-lamp. Her left lens had been removed and a post-operative adherent leucoma had blinded this eye. The other lens had a zonular cataract but the opacities were scattered through the center of the nucleus, with a heavy opacity at the inferior portion of the nucleus and some riders at the periphery of the nucleus.

A conference with this mother proved that she was familiar with the symptoms and appearance of cataract and that she remembered which of her relatives had congenital cataract. Hence, she became the propositus for the rest of the pedigree.

The great grandmother of the propositus is the affected female of Gen. I. Her two daughters in Gen. II had congenital cataracts but her son was normal. In Gen. III, three sisters and two brothers were affected but the youngest brother was normal. The oldest sib in Gen. III was the mother of our propositus.

One of the five sisters of the propositus, shown in Gen. IV, was affected and two brothers were normal. One male and two female cousins of the propositus were affected whereas four male cousins apparently were normal.

In Gen. V, we have already described the two affected daughters of the propositus. Their two male sibs apparently were normal. The four children of the unaffected identical-twin sisters of Gen. IV were normal. The daughter of a normal male in Gen. IV was not affected. An affected female in Gen. IV had an affected son and three normal daughters. Another affected female had an affected daughter and two normal daughters.

DISCUSSION

In Figure 1, thirteen of the seventeen cases are listed as females. The predominance of female cases could be due to the fact our propositus did not know the males as closely as the females in the pedigree.

Since every affected individual had one affected parent and since all marriages involving two normal individuals yielded normal children only, it is a dominant trait. It is likely that a simple dominant trait carried by genes on a pair of autosomes is involved in the L pedigree.

SUMMARY

While making a school visual survey, a girl with cataract was detected during retinoscopy and opthalmoscopy. From her mother, we received information on other members of the pedigree. The girl's sister, mother and fourteen other relatives had congenital cataracts while twenty-four apparently were normal. Slit-lamp examination of three of the cases revealed zonular cataracts of congenital origin. Every affected individual had one affected parent. In all marriages involving two normal individuals, none of the children were affected. This most likely is a pedigree of simple dominant, congenital, zonular cataract.

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AMERICAN JOURNAL OF OPTOMETRY
and ARCHIVES *of*
AMERICAN ACADEMY OF OPTOMETRY
Established 1924

Vol. 33 October, 1956 No. 10

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Publication and Academy Office: 1508 Foshay Tower, 821 Marquette Ave.
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Annual Subscription, United States and Canada, $7.00 in Advance; Foreign, $7.50: Single Copies 70c

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Published Monthly by the
AMERICAN JOURNAL OF OPTOMETRY PUBLISHING ASSOCIATION

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ONE HUNDRED YEARS OF PHYSIOLOGICAL OPTICS

The first volume of Helmholtz's *Handbuch der Physiologischen Optik* appeared in 1856 and it behooves us at this time to reflect upon the significance of this classic, and the progress that has been made in the ten decades that have passed since its publication.

Helmholtz divided the science of physiological optics into three parts:

1. The dioptrics of the eye.
2. The theory of the sensations of the nervous mechanism of vision.
3. The theory of the interpretation of the visual sensations.

The Handbuch appeared in three volumes, a volume being devoted to each of the subdivisions listed above. The first volume was published one hundred years ago, when Helmholtz was thirty-five years of age. The second volume appeared in 1860 and the final volume in 1866. A second edition of the Handbuch appeared in 1885. Following Helm-

holtz's death, a third edition was planned by Professors Gullstrand, von Kries and Nagel. Strange as it may seem these men chose to reproduce the original edition and to add their own supplements. This choice was made for two reasons. It was felt that the original was the classical work that marked the dawn of a new era in physiological optics. It was further felt that the changes which had been incorporated in the second edition had been called in question to a far greater extent than the contents of the first edition. It was this third edition that has been translated into English.

The Optical Society of America celebrated the hundredth anniversary of the birth of Helmholtz in Rochester, New York, in 1921. It was at this meeting that a committee was appointed to undertake the translation familiar to so many of us. James P. C. Southall was the chairman of this committee, and the English speaking world owes a great debt to this committee and its chairman.

In the two centuries preceding Helmholtz, great strides had been made in the understanding of the dioptrics of the eye and the mechanism of accommodation. The works of Kepler, Scheiner, Huygens and Young provided a mass of experimental and theoretical data which Helmholtz painstakingly sifted, tested, supplemented and finally integrated into a logical system which has withstood the test of these one hundred years. His constants for the schematic eye lie well within the limits of normal variation as determined by the most accurate methods available to modern science. His theory of the mechanism of accommodation, although vigorously attacked at one time, needed only the final polish which Fincham has recently provided in order to explain all of the facts associated with this act. His considerations of the aberrations of the optical system of the eye and the blur of the retinal image have furthermore withstood the test of time. Very careful and refined treatments of these subjects have appeared and have added significant refinements to the original data, but the basic concepts and conclusions have by no means been shaken.

The section on entoptic phenomena could very well be transplanted to a handbook of today without changing or adding a single word or phrase.

Our ophthalmoscopes of today are to a very large extent made to the specifications laid down in this great volume. It should give each of us great pride that we are privileged to use an instrument designed by one of the greatest scientists of all times.

Leonard T. Troland presented an address on the occasion of Helmholtz's centennial anniversary and in it he wisely counseled as follows:

"How many students of visual physiology are there at the present time endeavoring to solve problems the solution of which are to be found in the *Handbuch der Physiologischen Optik?* How many are there working without the knowledge which this great book silently offers as a guide in their endeavors? How many are there, moreover, who are dealing with fictitious or impossible questions the absurdity of which would be apparent to any close student of Helmholtz? Let us, who are living investigators of the phenomena of vision, resolve to read and comprehend from one cover to the other that great Bible of Physiological Optics which Helmholtz so painstakingly prepared for us." This advice, offered thirty-five years ago, still applies and in particular to the contents of the first volume.

HENRY A. KNOLL

DEPARTMENT OF BIOPHYSICS
UNIVERSITY OF CALIFORNIA
MEDICAL CENTER
LOS ANGELES, CALIFORNIA

ON CAUSES FOR CRITICISM IN OPTOMETRY

At optometric meetings the commercial optometrist (who is never invited to be present) is frequently criticized for his unethical methods of attracting patients or for his bait-advertising. This is probably a normal thing. A point usually made against the commercial optometrist is that his price advertising, or price cutting, lowers the general tone of practice and misleads the public as to the true and proper cost of visual care. This may be true, but only at rare intervals is the *professional quality* of commercial practice attacked, which is its weak point. Usually it is the price he charges for his services that draws the criticism.

In discussing this with optometrists, one is struck with this rather general attitude towards any optometrist whose fees are less than the local, average-top-fees of the profession. The price cutter is at once branded as a knave and charlatan. There is a demand that the State Board of Examiners do something about it. The same outspoken criticism is heard when a price-cutting dispensing optician moves into an area. Again, for a time, among some of the faithful, there is consternation.

Should this be the case? We think not. There is nothing sacred about optometric fees, nor should all optometrists charge the same fees. Under a system of private enterprise normal variations in fees are bound to exist and it is a good thing that this is so. The level of the fees are really much less important than the quality of work that is done.

Criticism should be leveled at any optometrist, or dispensing optician, who is shown to be doing a poor job, day-in-and-day-out, regardless of his charges or fees. To be effective the criticism must first be leveled at the quality of service performed and not the price.

It can be properly claimed that low fees and poor work, done in an hurried manner, go hand-in-hand. This is usually true, but the profession is on stronger ground in criticizing this problem, when the attack is made against the low standards of work and poor materials, than when made against the cut-price fees of the commercial artist.

Among other health professions the fees for similar services vary considerably. This is particularly true in the specialties. These variations cause little concern there, and the same should be true in optometry.

Perhaps optometrists are more price and fee conscious, because the costs of materials dispensed by optometrists are more familiar to the public than are comparable costs of dental materials or drugs. This is one of the reasons Koch[1] suggested that optometrists separate their professional and service fees, from their charges for materials, and dispense these materials to their patients at the prescription laboratory cost. Optometrists who follow this plan are known to be much less concerned with the activities of commercial optometrists or price cutting dispensing opticians, as they are not using a mark-up on materials, and the cost of these is known and seen in its true perspective.

The job of improving the standards of the profession is one that requires constant attention. Generally speaking, throughout the States and Canada the profession is already doing a fine job. Today, the great majority of optometrists meet most ethical and professional standards. It must be emphasized, however, that these standards are based upon good examination and refractive techniques; normal professional practice routines, and the use of first quality materials—not on price. Irrespective of the few advertising price cutters, optometrists who are doing a good professional job and who are giving their patients the best materials available, properly dispensed and serviced, will continue to enjoy successful practices. And what is equally important, they will enjoy the loyalty and confidence of their patients.

CAREL C. KOCH

[1]Carel C. Koch. Suggestions for a New Fee Structure in Optometry. Am. J. Optom. & Arch. Am. Acad. Optom. 29. 7. 331-340. Part I. 1952.

TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data, news, professional problems and ideals, as these relate to the Academy.

REVIEW OF PROGRAM FOR COMING ACADEMY MEETING

Dr. J. Donald Kratz, chairman, Papers and Program Committee, has announced that the following speakers will present papers at the General Sessions of the American Academy of Optometry, Shamrock-Hilton Hotel, Houston, Texas, December 8-11. This list will be augmented by several additional papers to be announced later.

Lenticonus—A Photographic Slit Lamp Study of the Anterior Surface of the Lens. Merrill J. Allen, O.D., Ph.D., Division of Optometry, Indiana University, Bloomington, Indiana.

Projection in Anomalous Correspondence. Neal J. Bailey, O.D., Division of Optometry, Indiana University, Bloomington, Indiana.

Visual Factors in Automotive Design. Paul L. Connolly, O.D., Royal Oak, Michigan.

Ametropia—A Longitudinal Study. Maurice M. Dalton, O.D., Alhambra, California.

The Optics of Plano Lenses, John K. Davis, A.B., Research Department, American Optical Company, Southbridge, Massachusetts.

Cosmetic Aspects of Ophthalmic Lenses. Margaret S. Dowaliby, O.D., Los Angeles College of Optometry, Los Angeles, California.

The Stiles Crawford Effect—A Theoretical Treatment. Jay W. Enoch, O.D., Ph.D., School of Optometry, The Ohio State University, Columbus, Ohio.

Objective Demonstration of Large Amounts of Fixation Disparity. Merton C. Flom, O.D., Ph.D., School of Optometry, University of California, Berkeley, California.

Pupil Size and Measurements of Veiling Luminance. Glenn A. Fry, O.D., Ph.D., School of Optometry, The Ohio State University, Columbus, Ohio.

The Effects of Duration and Background Luminance upon the Brightness Discrimination of an Amblyope. Ted Grosvenor, O.D., College of Optometry, University of Houston, Houston, Texas.

The Effect of Age on Visibility. Sylvester K. Guth, Ph.D., D.O.S., Lighting Research Department, General Electric Company, Nela Park, Cleveland, Ohio.

Practical Application of the Optometric Budget Plan. H. B. Hewett, O.D., Lake Charles, Louisiana.

The Effect of Measles on the Development of Myopia. Monroe J. Hirsch, O.D., Ph.D., Ojai, California.

Diagnosis and Prognosis in Amblyopia. Ralph W. LeDrew, O.D., Edmonton, Alberta, Canada.

The Resting State of Accommodation. Meredith W. Morgan, O.D., Ph.D., School of Optometry, University of California, Berkeley, California.

The Relationship of Close Work to Refractive Error in a Selected Junior High School Sample. Melvin Nadell, O.D., Los Angeles College of Optometry, Los Angeles, California.

Relationships of Reading Types to Uncorrectable Lowered Visual Acuity. Jack H. Prince, F.B.O.A., F.S.M.C., F.R.M.S., (Eng.). Department of Ophthalmology, University Hospital, The Ohio State University, Columbus, Ohio

Meeting the Educational Needs of the Partially Sighted. Alfred A. Rosenbloom, O.D., M.Sc., Illniois College of Optometry, Chicago, Illinois.

Convergence Accommodation in Presbyopia. Max Schapero, O.D., Los Angeles College of Optometry, Los Angeles, California.

The Recognition of Color. Arthur Schlaifer, O.D., Ph.D., Pennsylvania State College of Optometry, Philadelphia, Pennsylvania.

Vision and Rapid Reading. Howard N. Walton, O.D., Los Angeles College of Optometry, Los Angeles, California.

Field of View of Visual Aids. Gerald Westheimer, O.D., Ph.D., School of Optometry, The Ohio State University, Columbus, Ohio.

New Developments in Measuring Refractive Power of Ophthalmic Lenses. Donald B. Whitney, American Optical Company, Southbridge, Massachusetts.

A Survey of Orthoptics. Daniel Woolf, O.D., Ph.D., New York, New York.

Procedure and Results in Some Visual Training Cases. John Zettel, O.D., Cincinnati, Ohio.

SUB-NORMAL VISION SYMPOSIUM

As part of the General Sessions of the Academy on Sunday afternoon, December 9, the members and guests will hear and participate in a four-hour symposium on Sub-Normal Vision and its Correction. This program has been especially arranged by the Contact Lens and Sub-Normal Vision Section, Dr. Bernard Mazow, chairman. The speakers that will be heard during this afternoon panel are the world's leading specialists in this field and thus make this special attraction one

of great clinical significance. The program for this symposium follows:

Conditions Resulting in Sub-Normal Vision. Bernard Mazow, O.D., Houston, Texas.

Optics of Sub-Normal Vision Devices. V. J. Ellerbrock, O.D., Ph.D., School of Optometry, The Ohio State University, Columbus, Ohio.

Description of Sub-Normal Visual Aids. William W. Policoff, O.D., Wilkes-Barre, Pennsylvania.

Clinical Procedures in Fitting the Sub-Normal Vision Patient. John C. Neill, O.D., Pennsylvania State College of Optometry, Philadelphia, Pennsylvania.

Rehabilitation of the Sub-Normal Vision Patient. William Feinbloom, D.O.S., Ph.D., New York, New York.

Illumination for the Visually Handicapped. Sylvester K. Guth, Ph.D., D.O.S., Lighting Research Department, General Electric Company, Nela Park, Cleveland, Ohio.

THE SECTIONS

In addition to the preceding educational program of the Academy, the five Academy Sections, i.e., *Aniseikonia, Contact Lens and Sub-Normal Vision, Pathology, Orthoptics* and *Occupational Optometry* will each hold six hours of clinical and discussion periods during the convention. The programs of each of the Sections will be presented later.

SATURDAY NIGHT

The Papers and Program Committee have intentionally left Saturday night free so that members and guests would have the dinner hour and evening open to go-on-the-town in Houston. This is the only free time for sight-seeing during the heavily scheduled week.

THE BANQUET

The annual Round Table Dinner will be Monday night, December 10. The cocktail hour will be from 6:00 P.M. to 7:00 P.M., followed by the banquet. At the head table as speakers will be Dr. Rupert E. Flower, Visalia, California, president, American Optometric Association; General A. D. Bruce, president, University of Houston; Dr. Clanton W. Williams, vice-president of Academic Affairs, University of Houston and Dr. Meredith W. Morgan, Jr., past president of the Academy. Dr. John D. Perry, Jr., president of the Academy, will preside. Dinner coat and black tie is suggested.

REGISTRATION

Registration for the convention will start at 8:00 A.M. on Satur-

day, December 8. Dr. Rudolph Ehrenberg, chairman, Registration Committee, will be in charge.

BUSINESS SESSIONS

The first business session of the Academy is scheduled for one hour, 10:00 A.M. to 11:00 A.M., Saturday, December 8. The President's Annual Report will be presented along with other reports and announcements. The second business session is scheduled for Monday afternoon, December 10, at 400 P.M.

SAN JACINTO BATTLEGROUNDS

On Tuesday afternoon, December 11, following the close of the educational sessions, members and guests are invited to visit the San Jacinto Battlegrounds which will include a tour of the Museum and Battleship *Texas*. An 8:00 P.M. dinner has been planned at the famous San Jacinto Inn. For this event, members will travel by bus.

ARRANGEMENTS FOR HOUSTON TRIP

Optometrists now planning to attend the big educational meeting of the Academy in Houston, December 5-11, 1956, should formalize their travel and convention plans. The time is right for this, as only six weeks are left before the program starts. It is none too soon to make necessary arrangements and reservations.

Naturally the first thing to do is to decide how to get to Houston. Most optometrists will drive, if the experience of past annual meetings means anything. If you are driving you should now contact your Chamber of Commerce or Auto Club and determine the best roads for winter driving. If you plan to go by train, bus or plane you should start making your travel reservations now, as winter travel is always heavy, particularly towards the South.

Hotel reservations, too, must be made. The convention dates are December 5-11. The first three days will be taken up with post-graduate courses. These have been fully reviewed in our July and August issues and copies of these programs are available upon request. The last four days are devoted to the big educational sessions of the Academy, the General Sessions and the special meetings of the five Sections. You will want to stay at the Shamrock-Hilton Hotel as it will be most convenient. Make your hotel reservations now. Write to the Shamrock-Hilton Hotel, Reservation Department, Houston, Texas, giving the names of those who are coming with you, the type of accommodations you wish, and your date of arrival and departure. The hotel will schedule your reservation and take excellent care of you and your party. Rates vary, and you should indicate the price range you wish. Every choice may be accommodated.

To be assured of the exact Post-Graduate Courses of your choice, advance registration is advisable. While many courses will still be open on December 5, some will be sold out. To avoid possible disappointment you are urged to register now. Last year in Chicago about one-third of the courses were sold out when the convention opened, and the remaining courses were then filled. This necessitated changes in the plans of many optometrists who were obliged to select second or third choice courses, as those of their first preference were gone. Advance registration eliminates this possibility. Write to Dr. D. G. Hummel, National City Bank Building, Cleveland, Ohio, listing the courses you wish to attend and enclosing your check for registration. The check should be made payable to the Academy.

CONDENSED SCHEDULE OF COURSES

Course	Instructor	Subject	Hours	Periods
1	Abel & Heath	Elements of Graphic Anaylsis	4	W-4, W-5, T-4, T-5
2	Allen	Raubitscheck Test for Astigmatism	2	W-2, W-3
3	Allen	Subjective Testing Procedures	2	T-8, T-9
4	Alpern	Recent Advances in Visual Science	2	T-2, T-3
5	Alpern	Phorias:—Physiological Considerations and Practical Applications	2	F-8, F-9
6	Bailey	Amblyopia, Suppression and Related Phenomena	2	F-8, F-9
7	Bannon, Connolly, Freeman, Madigan & McCulloch	Aniseikonia and Space Eikonometry	6	W-E, T-E, F-E
8	Bannon	Presbyopic Corrections—Physiological Basis	1	W-1
9	Bannon	Management of Difficult Refractive Problems	1	T-1
10	Bechtold	Design of Eikonic Lenses	3	T-12, F-4, F-5
11	Bechtold	Optical Aids for Subnormal Vision	3	W-8, W-9, F-10
12	Bing	Vision Screening for School Children	3	W-12, T-12, F-12
13	Copeland	Streak Retinoscopy	4	W-10, W-11, T-10, T-11
14	Dowaliby	Design in Eyewear	2	T-1, F-1
15	Enoch	Turville Infinity Balance Test	2	F-10, F-11
16*	Feinbloom & Filderman	Visual Rehabilitation of the Partially Blind	3	W-4, W-5, T-4
17	Flom	A Minimum Strabismus Examination	2	W-4, W-5
18	Fry	Color Vision Testing	1	F-11
19	Fry	Analysis of Problems with Retinoscopy	1	F-2
20	Giglio	Measurement of Central Scotoma	1	T-5
21*	Graham, Feinbloom, Neill & Policoff	Advanced Course in Contact Lenses	8	T-10, T-11, T-2, T-3, F-10, F-11, F-2, F-3
22	Guth	Light and Lighting for the Optometrist	2	F-E

CONDENSED SCHEDULE OF COURSES (Continued)

Course	Instructor	Subject	Hours	Periods
23	Hirsch	Multifocal Lenses for Anisometropic Patients	1	W-12
24	Section on Pathology, AAO	Review of Ocular Pathology	6	W-E, T-E, F-E
25	Hofstetter	Optometric Economics	1	F-1
26	Hofstetter	Advanced Graphic Analysis	2	F-4, F-5
27	Jobe	Fundus Photography	2	F-2, F-3
28	Kroeger	Ocular Pharmacology	2	W-2, W-3
29	Langsen	Administration of Vision Programs in Industry	2	T-8, T-9
30	McCary	Neurosis in Optometric Practice	2	W-E
31*	Mazow	Introduction to Slit Lamp Microscopy	3	W-1, T-4, T-5
32	Morgan	The Role of Surgery in the Treatment of Squint	2	T-E
33	Morgan	Simple Objective Testing Procedures for Motility	1	W-1
34	Murroughs	Strabismus Testing and Diagnosis	3	T-8, T-9, F-12
35*	Neill & Associates	Beginning Contact Lens Fitting	8	W-10, W-11 W-2, W-3, T-10, T-11, T-2, T-3
36	Prince	The Recognition of Early Pathology	2	W-10, W-11
37	Schapero	Home Training for Orthoptics	2	W-8, W-9
38	Shulman	Fitting a Ptosis Crutch	1	F-3
39*	Simmerman & Hirsch	Glaucoma and Tonometry	4	F-8, F-9, F-4, F-5
40	Simmerman & Hirsch	Visual Fields and Perimetry	3	W-12, T-12, F-12
41	Wick & Koch	Practice Management	2	W-8, W-9
42	Woolf	Fixation Disparity as a Diagnostic Method	2	T-1, F-1

*In each Course the enrollment is generally limited to thirty. In Courses marked with an asterisk (*) the enrollment is limited to a smaller number because of the clinical or instrumental character of the course.

In addition, for those optometrists wishing to take a pre- or post-convention tour of Mexico—and it will be a wonderful experience—the time to plan this is now. Write to the Harvey Travel Bureau, c/o Mr. D. Stuart Godwin, 2005 W. Gray Ave., Houston, Texas, for the schedules and costs of these special seven-day all-expense optometric tours. This will make an excellent winter vacation and the tours may be taken either before or after the convention itself.

CAREL C. KOCH.

ABSTRACT

SCOLIOSIS AND VERTICAL OCULAR MUSCLE IMBALANCE. Albert D. Ruedemann, M.D., Archives of Ophthalmology. 56.3. 389-414. 1956.

At frequent intervals there appears in the optometric literature references to the general subject of torticollis* and sundry manifestations. In general the data is incomplete and lacks proper supporting evidence. Optometrists are therefore vaguely aware of the subject-matter but without an actual comprehension of the fundamentals involved. This outstanding paper, which may well become a classic, illustrates specific cases replete with X-rays and detail of patients with spinal scoliosis** produced when a vertical muscle weakness is present from birth.

The author of the paper presents the first analysis of its type, of a vital subject often discussed quite loosely and seldom fully appreciated. There are two general groups, those who maintain fusion and those who do not, with the maintenance of fusion not necessary, in order for the scoliosis to persist. The scoliosis apparently develops shortly after birth in response to a desire for ocular bifixation. The 20 X-rays along with the excellent diagrams supports the paper most admirably. A "must" for the adequate optometric library.

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*Torticollis is a spasmodic contraction of the muscles of the neck, chiefly those supplied by the spinal accessory nerve. In this condition the head is drawn to one side and usually rotated so that the chin points to the other side.

**Ocular scoliosis has been thought to be caused by head tilting with the resultant cervical curve of the spine. At one time uncorrected oblique astigmatism was thought to be the cause of the original head tilt.

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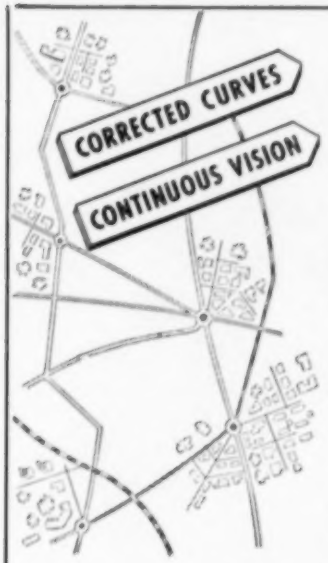

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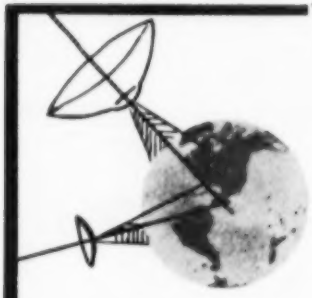

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CONVENTION TOUR TO MEXICO CITY

(Before or after the Academy meeting in Houston)

The Harvey Travel Bureau has been appointed as the official tour operator for the post-convention tour to Mexico in December.

Those coming from the North and East may not realize that Mexico City is only three and a half hours from Houston and that this would be a golden opportunity to visit South of the Border. Since the trip from the home city to Houston would be deductible, the additional transportation cost to Mexico City would be a minor expense.

A seven-day tour, including a City Tour, Xochimilco, Pyramids, Shrine of Guadalupe, Taxco, and Cuernavaca, has been set up. For those who can spend a few days longer, there is a three-day extension to Acapulco.

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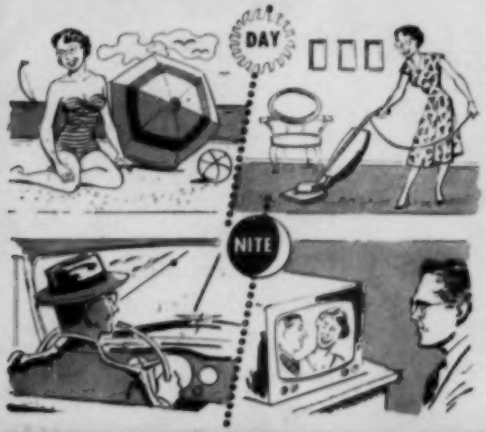

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